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CLIMATIC NORMALS AS PREDICTORS
Part 3: Median vs. Mean

by

WILLIAM F. SLUSSER
SAN FERNANDO VALLEY STATE COLLEGE

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SAN FERNANDO VALLEY STATE COLLEGE FOUNDATION
NORTHRIDGE
(Los Angeles)
Calif. 91324

CONTRACT MONITOR: IVER A. LUND
Aerospace Instrumentation Laboratory

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UNITED STATES AIR FORCE
BEDFORD, MASSACHUSETTS
01730

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PART III: MEDIAN VS. MEAN

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San Fernando Valley State College
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ABSTRACT

Rainfall and other variables with similarly skewed distributions are hard to characterize climatically due to their extreme variability. The arithmetic mean, generally used, is greatly influenced by extreme values. For rainfall data from 219 stations located in the western United States, the median was found to be a more representative value, and somewhat better than the mean for predicting future rainfall amounts. Some monthly precipitation frequency distributions are so greatly skewed that values smaller than the mean occur 90% of the time. Because any single measure of central tendency is inconclusive, measures of absolute and relative variability are summarized. Maps of percentage occurrence of the mean, ratio between median and mean, coefficient of variation (CV), and relative variability (Vq) are presented for the mid-season months--Jan, Apr, Jul, and Oct.

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CHAPTER I

INTRODUCTION

The part played by numerical material in geography has been progressively widened in recent years, but the methods of generalizing therefrom have remained substantially unchanged. The arithmetic average, or mean, is still the most widely used value to characterize a set of observations. It is the purpose of this thesis to examine the suitability of the mean as a measure of central tendency in non-symmetrical distributions, and the possible advantages of the median over the mean.

The introductory chapter is concerned with the reasons for the acceptance of the mean, and with previous studies dealing with the median and mean. Chapter II, "Climatic Normals," presents a detailed study of one instance where the mean is being used to represent non-normally distributed data. Chapter III, "Measures of Dispersion," points out the limitations of any single value in portraying the distribution of a set of observations. The final chapter, Chapter IV, "Climatic Prediction," demonstrates the application of knowledge gained from previous chapters in the solution of a practical problem.

1.1 Limitation of Study

Although there has been an increasing use of numerical analysis in climatology, the statistics being used to analyze the masses of data have gone unchanged. The statistics presently in use were developed for use with normal or near normal samples. Chief among these are the two most commonly used statistics, the mean and the standard deviation.

Unfortunately, most climatic variables have distributions other than normal. Singly or doubly bounded variables have skewed distributions markedly different from the symmetry of the normal distribution (Section 2.5). Precipitation, wind speed, insolation, and visibility are a few of the climatic variables for which the majority of observations occur at the upper and/or lower limits of their distributions. In such skewed distributions the mean and standard deviation do not have all the useful properties as in the normal distribution. Perhaps the median, and measures of dispersion about it, may be more useful.

Although the discussion will be limited to the use of the mean and median in summarizing precipitation data, the results should be equally valid for other non-negative variables having substantial frequencies near the lower bound, and thus having similarly skewed frequency distributions. Wind speed, income, and agricultural, industrial, or mineral production by counties, are good examples of such variables.

1.2 Use of Mean and Median

The arithmetic mean is often declared to be the best estimate of central tendency, and hence is the value most generally used to characterize entire sets of observations. In a symmetrical distribution, such as the normal, the mean is also the median or 50% probability value. Thus many people implicitly regard any mean as having a 50% probability level of exceedance. Unfortunately, in skewed distributions, which are more common for geographic data, the mean is not the median, and only the median has a 50% probability level of occurrence.

The greater the skewness of the distribution, the poorer the mean becomes as an estimate of the middle value, the median. While the mean may be easier to work with in many instances, the median or 50% probability value is most often desired and should be used whenever possible to avoid any misconceptions regarding frequency of occurrence. In many applications the mean has been used, and is continuing to be used, largely as an approximation of the median.

1.3 Early Studies

The unsuitability of the mean as a measure of central tendency in climatological research has long been realized, but it was not until 1933 that a serious attempt was made to replace the mean with the median to summarize a "varied meteorological record." It was in this year that the British geographer, Percy Robert Crowe, introduced the use of the median and quartile deviation (half the difference between the upper and lower quartiles) in a study of European rainfall entitled "Analysis of Rainfall Probability." This study created much interest and its influence can be seen in several succeeding studies. The most notable of these is a study of Indian rainfalls by Matthews (1936). The median and quartile deviation were again used by Crowe (1936) to study the rainfall regime of the Western Plains of the United States, and also by Lackey (1937) in constructing annual-variability maps of the Great Plains. Earlier studies by Lackey (1935, 1936) also show the influence of Crowe.

Other researchers not influenced by Crowe were also coming to the conclusion that the mean should be replaced by the median when dealing with a highly variable distribution. Gisborne (1935) used monthly precipitation records of Spokane, Washington to show that the mean is a poor value to use as a "climatic normal." He found that the mean was never reached or exceeded more than 46% of the time in any month and that in June the mean occurred only 26% of the time. If the mean were used as the "normal," 74 years out of 100 had below normal precipitation in June. A similar study was undertaken by Mindling (1940) using 60 years of monthly precipitation records for each of 14 stations distributed throughout the United States. His conclusions were the same as Gisborne's: the mean is an unsatisfactory value to use as a "normal," and that the median would be a better value to use.

This interest in the proper statistic for use in representing a non-symmetrical distribution, first seen in the studies by Crowe, reached a peak June 20-21, 1940. At this time a resolution recommending that "the expression of normals of precipitation in future hydrologic studies be defined by the median instead of the arithmetical average" was presented to the Section of Hydrology of the American Geophysical Union, meeting jointly with the Western Interstate Snow-Survey Conference in Seattle. A committee headed by P.E. Church (1941) had weighed the advantages and disadvantages of each (Chart I) and concluded that "in the future, at least for hydrologic studies, the expression of normals of precipitation be defined by the median."

Unfortunately the recommendations of this committee were lost with the on-coming of World War II, as was the interest stimulated by Crowe and others, and the mean continues to be used in hydrologic and climatological studies.

1.4 Recent Studies

Very little discussion of this topic has appeared since 1941. Landsberg (1947), declaring that the mean does not represent the usual condition even for monthly temperatures, condemned the use of the term "normal" for the arithmetic mean. In a study of rainfall on Oahu, Hawaii, Landsberg continued, saying that:

> The median is the statistic that preserves one of the most important properties of a "normal." It represents the center of the distribution and half of the observations are higher, the other half lower than this value. (1951, p. 9)

CHART 1

REPORT OF COMMITTEE ON MEDIAN VERSUS ARITHMETICAL AVERAGE

P. E. Church (Chairman), Edward L. Wells, and H. P. Boardman

In the last session of the meetings of the Section of Hydrology of the American Geophysical Union in Seattle in June, 1940, a resolution recommending that "the expression of normals of precipitation in future hydrologic studies be defined by the median instead of the arithmetical average" was presented. It was moved, seconded, and passed that the resolution be referred to a committee appointed by Chairman J. C. Stevens, composed of P. E. Church (Chairman), Edward L. Wells, and H. P. Boardman. [See p. 1063, Trans. Amer. Geophys. Union, 1940.]

The Committee then weighed both the advantages and disadvantages of the median and the arithmetical average and in so doing numerous arguments, both favorable and unfavorable, were brought out.

Though there are numerous ways of expressing the central tendency of a series of observations, (a) arithmetical average, (b) geometric mean, (c) harmonic mean, (d) weighted arithmetical average, (e) mode, (f) median, and (g) frequency-distributions, the resolution called for a recommendation of the use of median in preference to the arithmetical average.

These disadvantages and advantages of the median versus the arithmetical average are listed and discussed below:

<u>Disadvantages of the median</u>

(1) The median, as the method of expressing the normal, is not always the figure which will be representative of the central tendency for all purposes. For certain purposes the arithmetical average is more useful.

(2) A large amount of work will be required to recompute the vast amount of data on record now available. This work would fall largely on the Weather Bureau which has amassed the greater part of the data now in use. The Weather Bureau does not have sufficient assistance to recompute this body of data at present.

(3) Comparatively few people outside the mathematical and engineering profession understand the exact meaning of the median whereas nearly everyone understands how the arithmetical average is computed. If the median was used it would be necessary to instruct those using the data as to the meaning of the median.

(4) When there is an extended number of observations, the arrangement of the data to determine the median is tedious and although no computation is necessary to determine this figure there is no machine on the market which will make the necessary arrangement. It is a simple and quick process to compute the arithmetical average because adding machines are almost universally available.

(5) The sum of the monthly medians for a year does not equal the annual median, whereas the sum of the monthly arithmetical averages equals the annual arithmetical average. The annual median would have to be computed from the annual amounts.

(6) Where more than half the figures in a series are zero, the median would convey the impression that there was a lack of a measurable quantity.

<u>Advantages of the median</u>

(1) The median, while not always the figure which will be representative of the central tendency for all purposes, is superior to the arithmetical average in many cases.

(2) The median can be determined by a simple arrangement of the series of observations and no computation is necessary. Where adding machines are not available, the determination of the average is far more tedious than the median.

(3) The median is unaffected by the abnormally large or small values of a series of observations. In the case of precipitation the abnormal values are always in excess of both the median and the arithmetical averages because of the limiting value of zero. The arithmetical average is "strongly influenced by extreme variants in a series of values."

(4) In the series of observations, if there is a <u>greatly</u> outlying value, either real or the result of an error, the median will be less affected than the arithmetical average.

(5) Negative departures of precipitation are of greater frequency than plus departures when the arithmetical average is used as the measure of the central tendency. This would not be true when the median is employed.

(6) Those who would make active use of the median as the normal are mainly hydrologists, engineers, meteorologists, etc., who would not have to be instructed as to the meaning of median. Those who do not know what the word median portrays could learn that as readily as the content of arithmetical average, normal, or mean. On published data a definition of median could be inserted.

In the study of the measurement of water content of a snow course, Court (1958) found that a water equivalent figure sufficiently accurate for the practical use to be made of it can be obtained from the median of a small number of snow course points. He indicates that the combination of a larger number of snow water content measurements into a single mean is "a gross waste of information from the statistician's standpoint."

More recently Joos (1964), after a study of the variability of weekly rainfall, suggested that "a more meaningful 'normal' for weekly precipitation might be based on the 50% value rather than on a long term mean." Kangieser (1966) finds that in some parts of Arizona only one year in ten has monthly precipitation as great as the mean value. And Bennett (1967) shows the median to be a better statistic than the mean for the study of insolation which, unlike precipitation, has a distribution in which many observations occur near the upper bound.

1.5 The Mean as a Poor Estimate of Central Tendency

The mean is too strongly influenced by the extremes in a series of values. Ten months with values one unit below the mean are required to neutralize the effect of one month with a value ten units above the mean. In the case of climate, it is the time period during which people have to live and work, the month of the year, that is significant.

The frequency of departures from the normal is important, but the actual extent of departure of each instance is secondary.

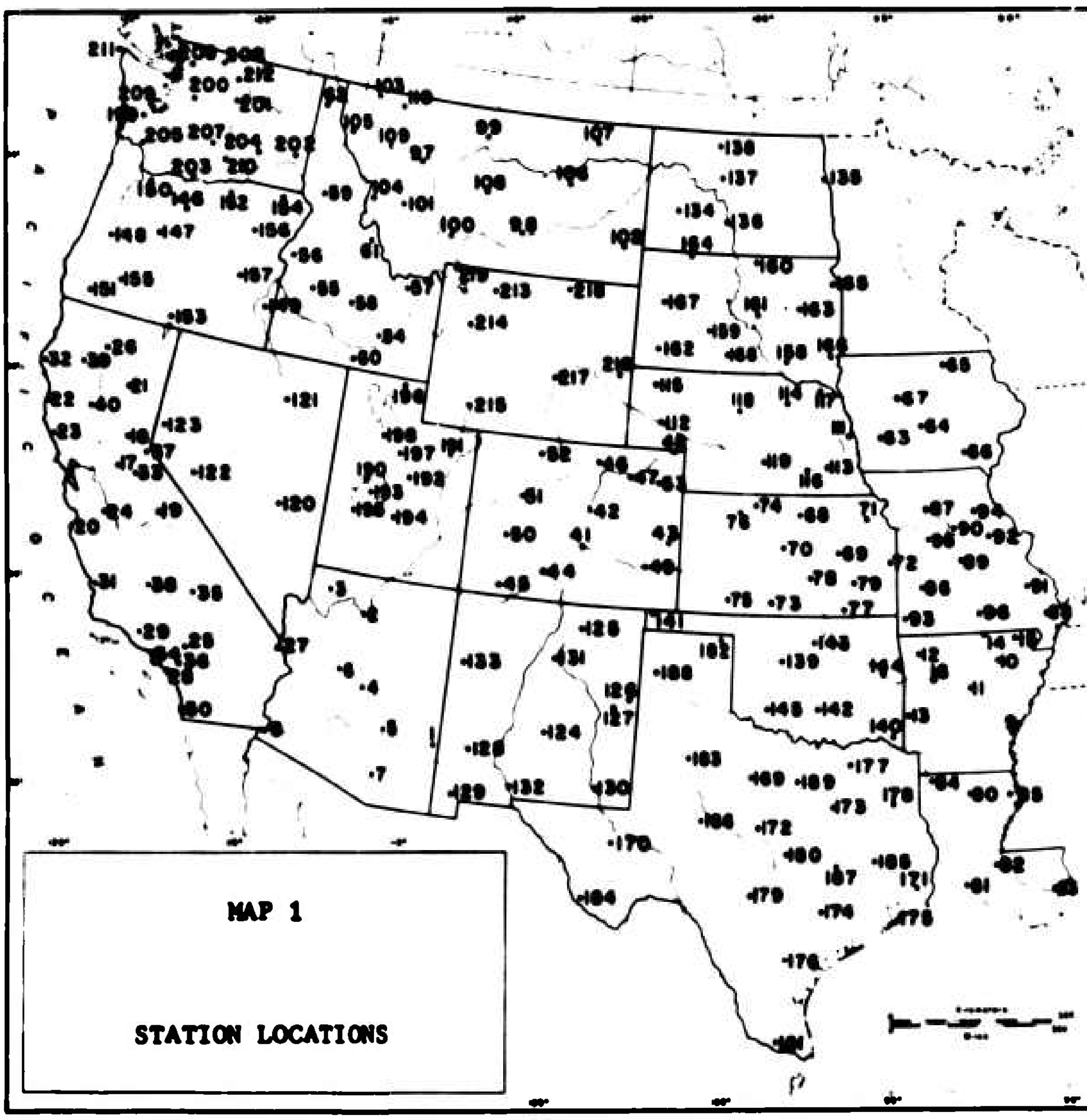
Yet, it is the mean which is stated in answer to a question concerning the amount of rainfall a place receives. At the present time, maps of climatic normals are based on the arithmetic mean such as those which appear in _The National Atlas of the United States_, published in 1964. The supposed purpose of these "normal total precipitation" maps is to give the user an idea of the most likely amount of precipitation to be received at a particular place. Since the arithmetic mean can satisfy the concept of normal only when the data are symmetrically distributed, these "normal total precipitation" maps are deceptive especially in drier areas of this country.

It would seem that the median would be a much more logical measure of central tendency. Since it is the middle value, it is easily ascertained when the figures are arranged in ascending or descending order of magnitude and can thus be located by a process no more complicated than simple inspection or, at most, by plotting the values concerned on some form of linear graph. With the use of the high speed computers, even large amounts of data pose no problem in the finding of the median. Its reality consists of the fact that, since half of the records exceed it and half of them are less, it represents the usual or typical value. It is quite independent of a few very exceptional values, since each value has an equal pull, whatever its size. Because of this, the median is less sensitive to errors which might be present in the data being examined.

1.6 Normals

At the present, one of the primary methods used to portray climatic data is through the use of a 'climatic normal.' Climatic normals supposedly describe the climate of a place or region and are often used to estimate future climatic conditions. They are calculated by averaging climatic events over a number of years, usually 30. Although some objections have been voiced against this method of determining the normal, it is accepted as being the best possible method by the majority of the people.

As pointed out by Gisborne in 1935, the concept of normal is well established in both the technical and the lay mind as that which is common, natural, ordinary, regular, typical, and usual. It must be determined just how well the mean satisfies this definition.



MAP 1

STATION LOCATIONS

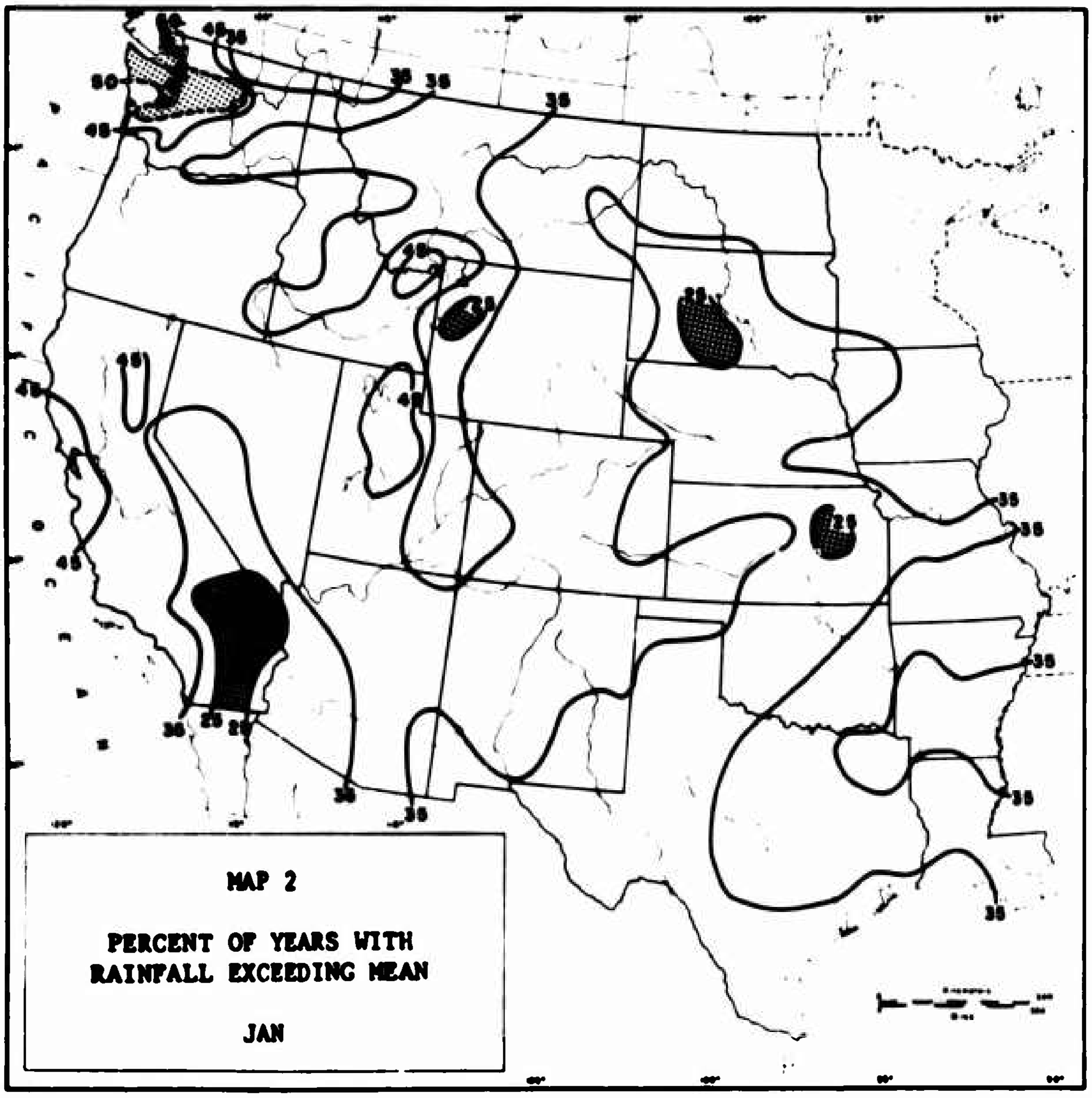
CHAPTER II

CLIMATIC NORMALS

2.1 Data and Study Area

Used in this study are monthly precipitation values at 219 stations in the United States, all west of the Mississippi River (Map 1). Data were taken from publications of the United States Weather Bureau, supplemented by data published by various states. Stations were selected to insure homogeneous data: no significant change in station position, elevation, or environment during the observation period. Although some stations had precipitation records for 110 years of continuous observations, only data from the period 1931 to 1960 were used. Thus all analyses and maps in this report are comparable, and are for the period specified by the World Meteorological Organization and used by the United States Weather Bureau to determine climatic normals.

Table 1 (Appendix 1) is a list of the monthly precipitation stations used in this study. The 219 stations represent an average density of one station for every 9,789 square miles. While this falls short of the one station per 1,029 square miles coverage for rainfall by the *National Atlas of the United States*, it compares favorably with the density of stations of the *Local Climatological Data* published by the United States Department of Commerce Wea-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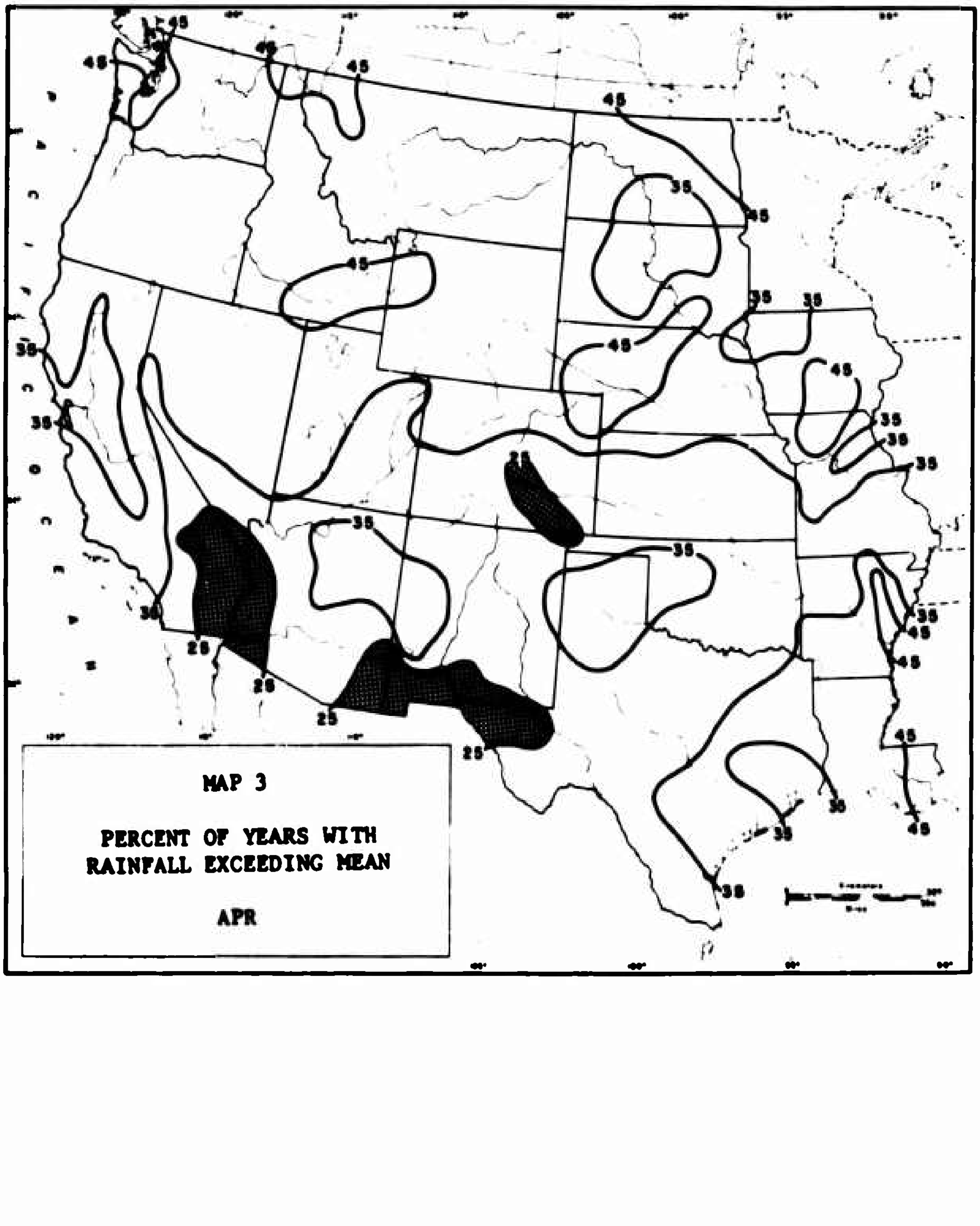
MAP 2
PERCENT OF YEARS WITH
RAINFALL EXCEEDING MEAN
JAN

ther Bureau (approximately one station per 10,500 square miles). Stations are listed by their U.S. Weather Bureau identification number, with name, coordinates, and number of years of continuous record. For convenience in computation and mapping, stations are also numbered serially 1 to 219.

Due to the excessive time and work involved in mapping the results of all months, only the mid-season months of January, April, July and October are included in this study. The use of these months should bring out any seasonal variations that may exist, and should be a large enough sample to work with. It is important to work with more than one or two months since the possibility does exist that they may not be representative of the majority of months. Such an error was made by McClean (1956) in assuming that conclusions reached for one month would apply to all months. McClean's contention that the period 1881-1915 is a poor one to use as the standard for reference to British rainfall was disproved by Glasspoole (1956).

2.2 Procedure

If the climatic normal were a representative value, it would be expected to be reached in half of the years of record. The percentages of the years (1931-1960) in which the "normal" value was reached or exceeded were calculated and are shown on Map 2-5. These maps show that the mean



MAP 3

PERCENT OF YEARS WITH RAINFALL EXCEEDING MEAN

APR

fails to represent the central value of the distribution from which it is derived, especially for the Southwestern portion of the country. The inadequacy of the mean as an expression of the "normal" for monthly precipitation is shown.

2.3 Skewness

As stated in the introduction, in a normal distribution, or any other symmetrical distribution, the mean is equal to the median and under such circumstances the mean is a perfectly valid value to use. But when the distribution is skewed (asymmetrical), the mean is much less representative. A distribution is symmetrical when the median equals the mean; positively skewed when the mean is larger than the median; and, negatively skewed when the mean is smaller than the median.

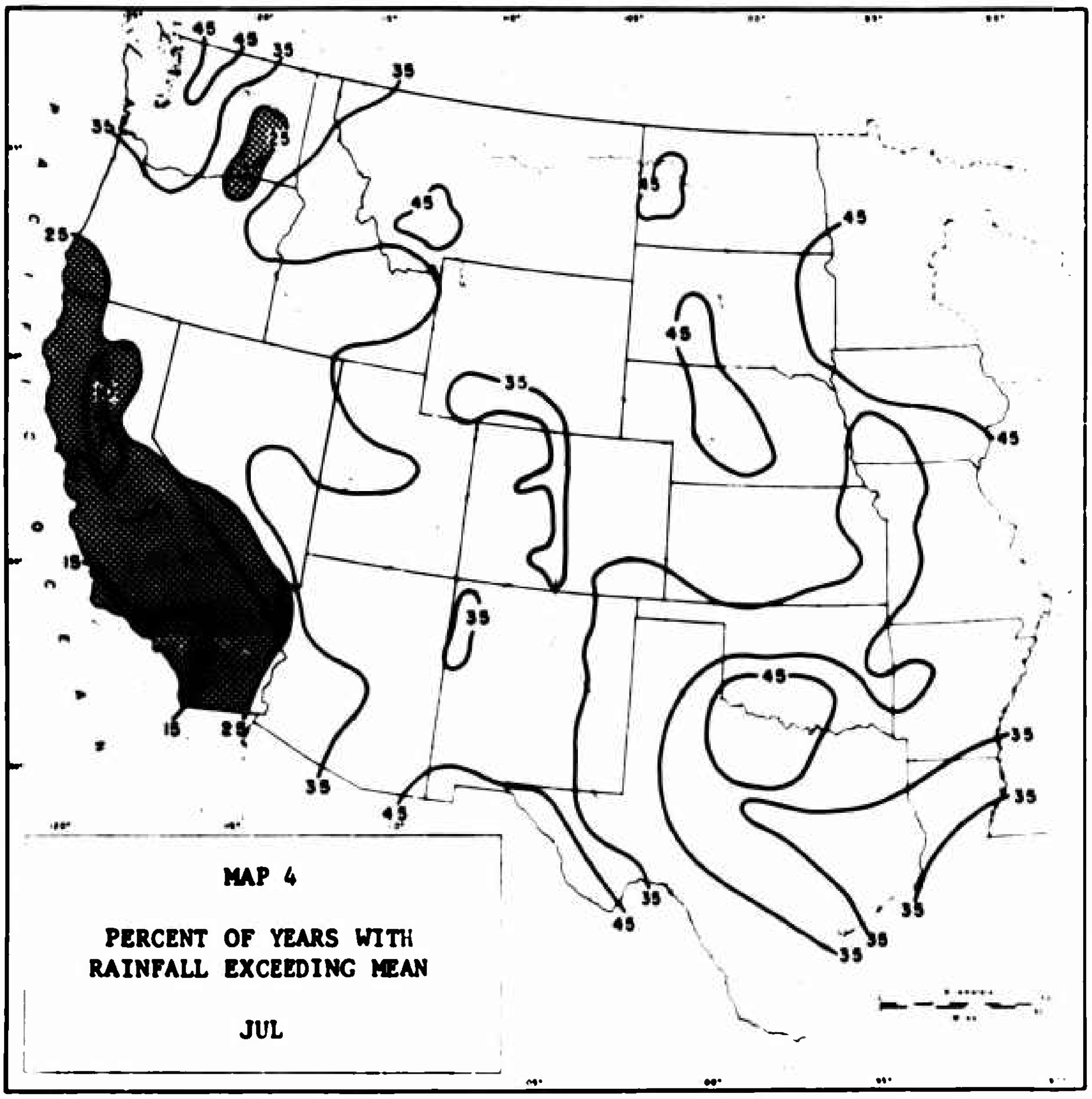
There are several ways for measuring skewness. One of these is the "Pearsonian coefficient of skewness" given by the formula

$$3(\text{mean} - \text{median})/\text{standard deviation}$$

Another measure, α_3 (alpha-three), is defined in terms of the second and third moments, m_2 and m_3, about the mean as

$$\alpha_3 = m_3/(\sqrt{m_2})^3$$

In this study a simple measure of skewness is given by the percentage occurrence of the mean as portrayed in Maps 2-5.



MAP 4

PERCENT OF YEARS WITH RAINFALL EXCEEDING MEAN

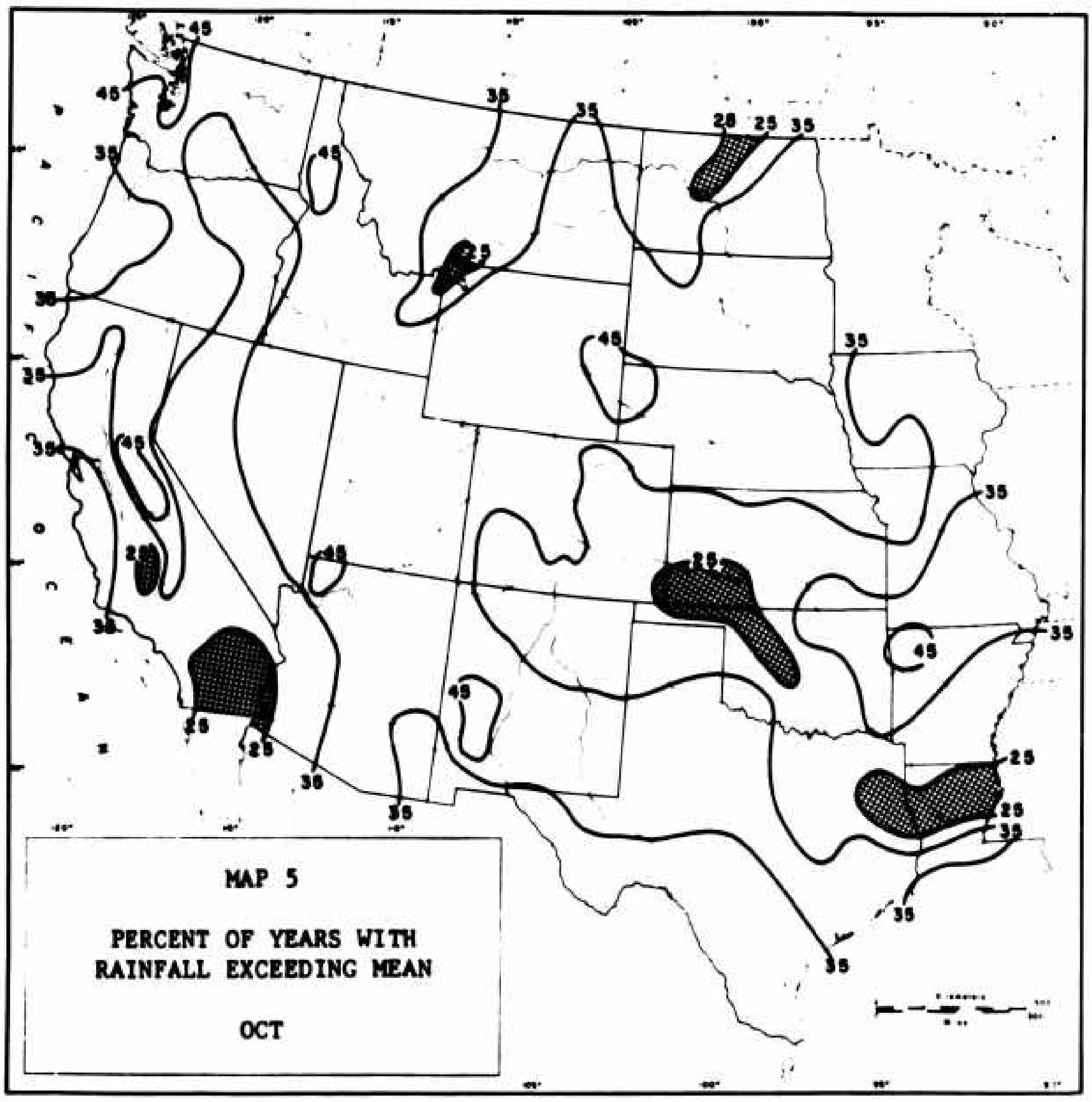
JUL

The further the mean departs from the 50% probability value, the greater the skewness and the greater the advantage in using the median to best represent what is expected to happen again.

2.4 Analysis of Maps

Before discussing the maps any further, it should be pointed out that isolines are only as good as the data from which they are derived. The patterns shown on the maps in this study are necessarily general due to the number of stations used. If further data points were available, patterns would undoubtedly be changed. But for the purpose of the present study the number of stations is adequate. If further detail is desired, studies of individual states should be made, such as that of Arizona by Kangieser (1966). It would have been of interest to compare his maps with the ones in this study, but unfortunately they are of different months.

All maps show low values to occur with regularity in the Southwest, while high values occur in the Northwest. The mean is reached in as many as 50% of the years only for January in the northwestern section of Washington. If the mean were a good value to use as a climatic "normal," it should have been reached in half the years in all parts of the country. But it is reached in less than a quarter of the years in many areas of the country, and in fewer



MAP 5

PERCENT OF YEARS WITH RAINFALL EXCEEDING MEAN

OCT

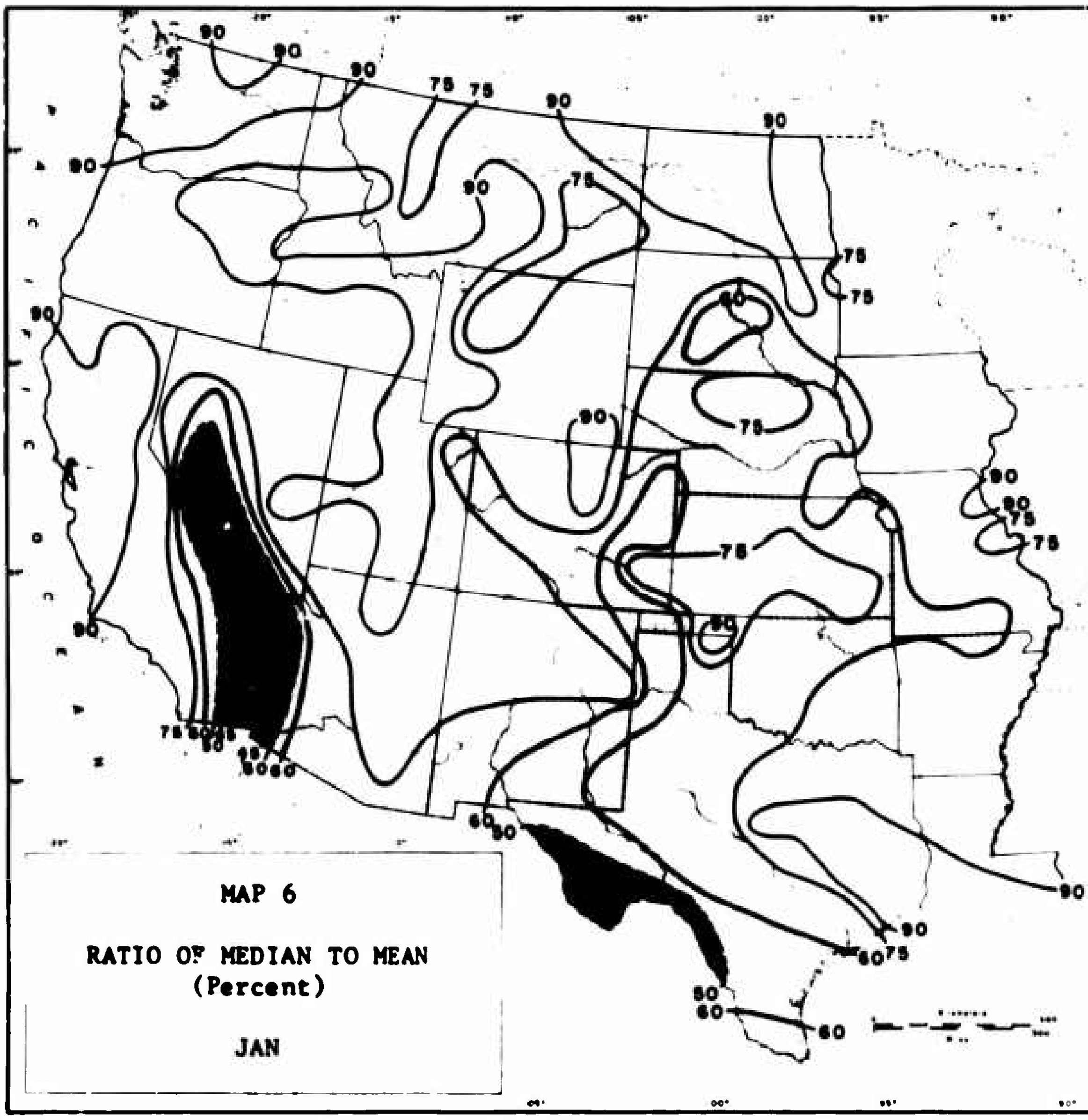
than one year in ten for the Central Valley of California in July.

Seasonal variation in the occurrence of the mean can best be seen in central California. Here the values range from less than 10% in July to over 45% in January.

For all months values from 35% to 45% are most common. There can be seen no general longitudinal or latitudinal gradation of values, and the only consistencies are the low values of the southern California desert and the high values of northwestern Washington.

2.5 Conversion of Existing Maps

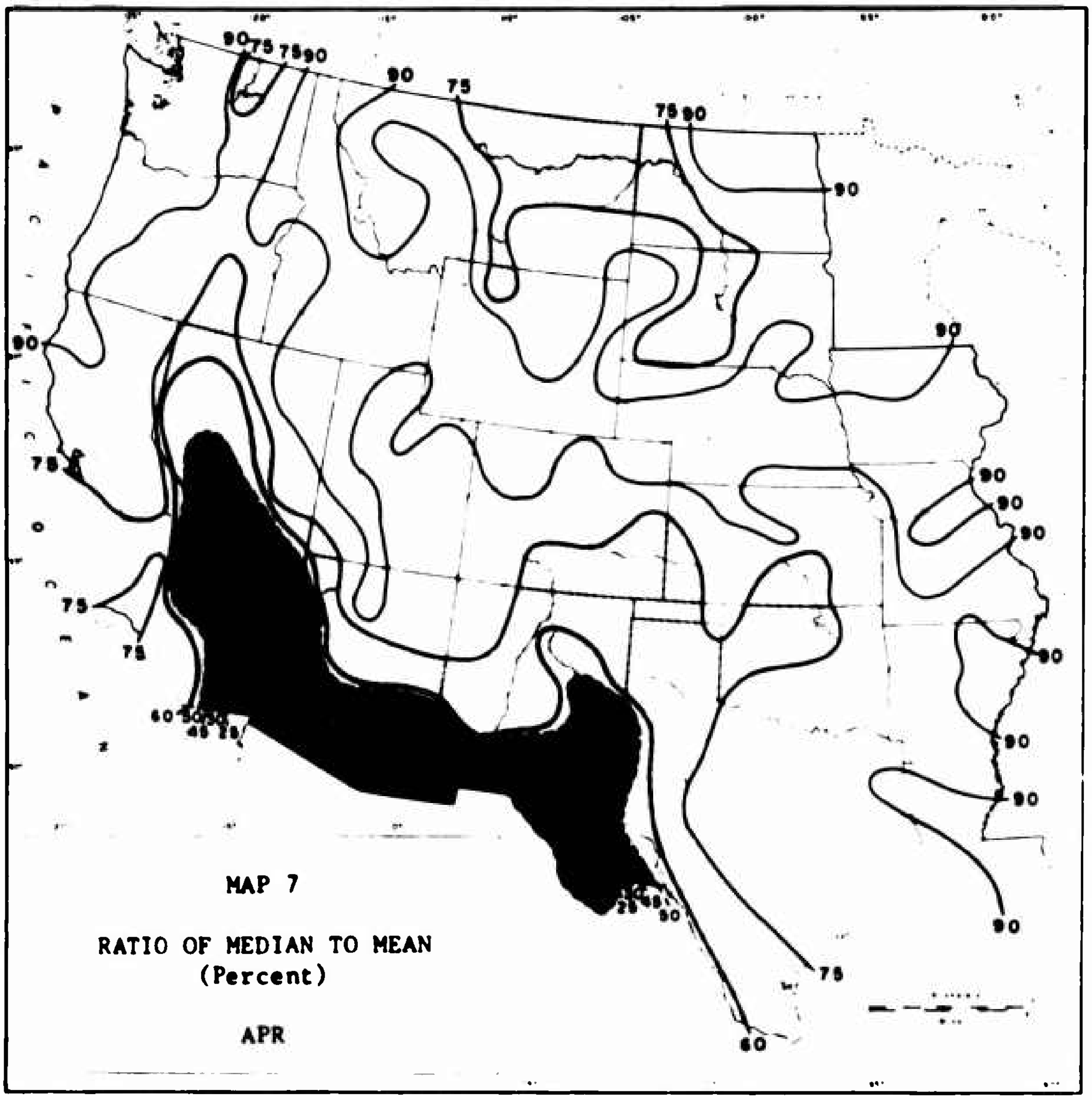
If a distribution proves to be skewed, the use of the mean as the most representative value of the distribution will be misleading. Under such circumstances the median should be used. However, considerable work went into the computation of existing means, and it is doubtful that anyone would be willing to discard these even if their validity is in doubt. This problem would be solved if a stable relationship is found to exist between median and mean. With this aim in mind, the ratio between median monthly and mean monthly values was computed for each station (Maps 6-10). If stable, these ratios can be used as correction factors to convert existing means to medians (see Appendix).



MAP 6

RATIO OF MEDIAN TO MEAN
(Percent)

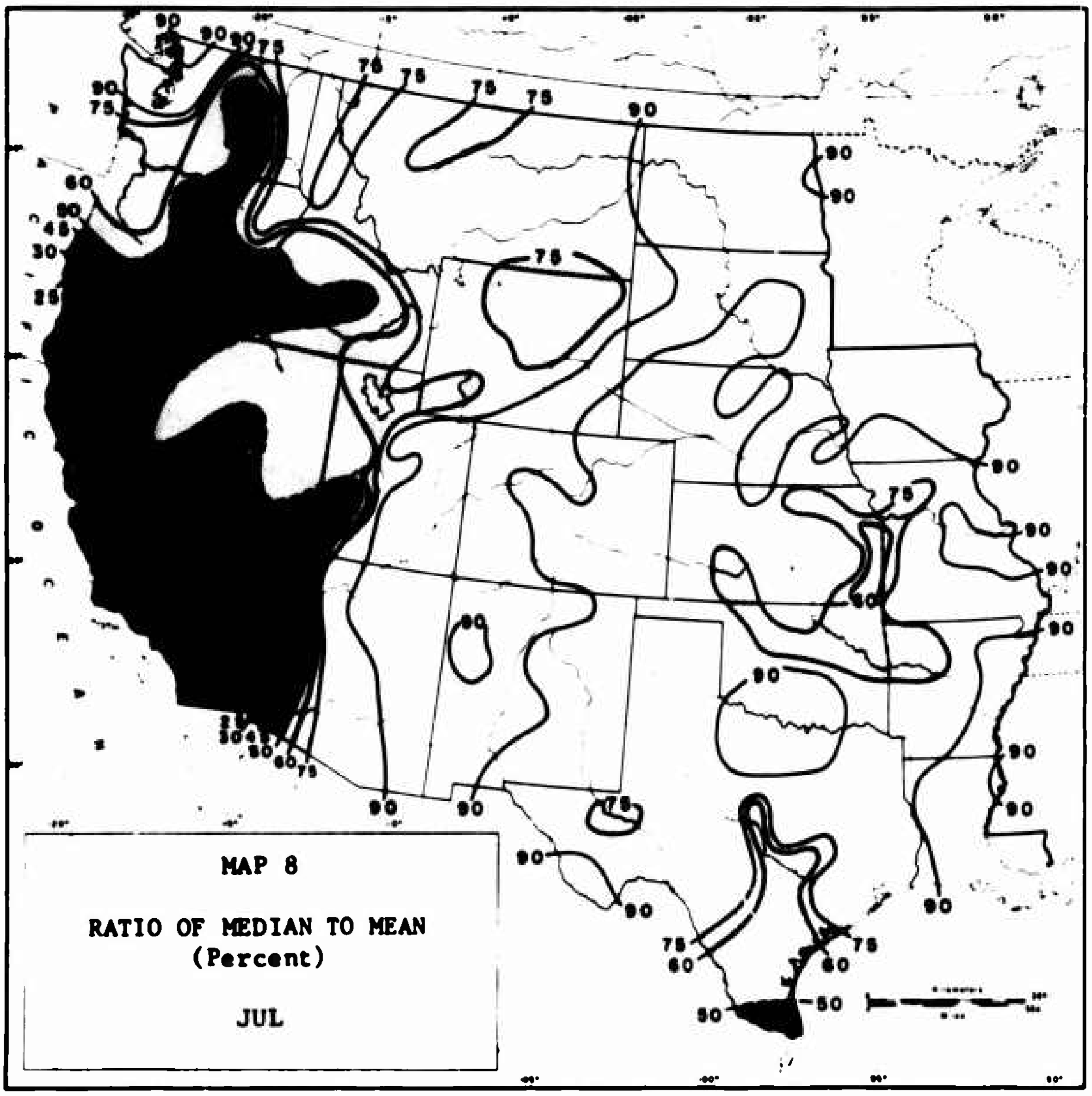
JAN



MAP 7

RATIO OF MEDIAN TO MEAN
(Percent)

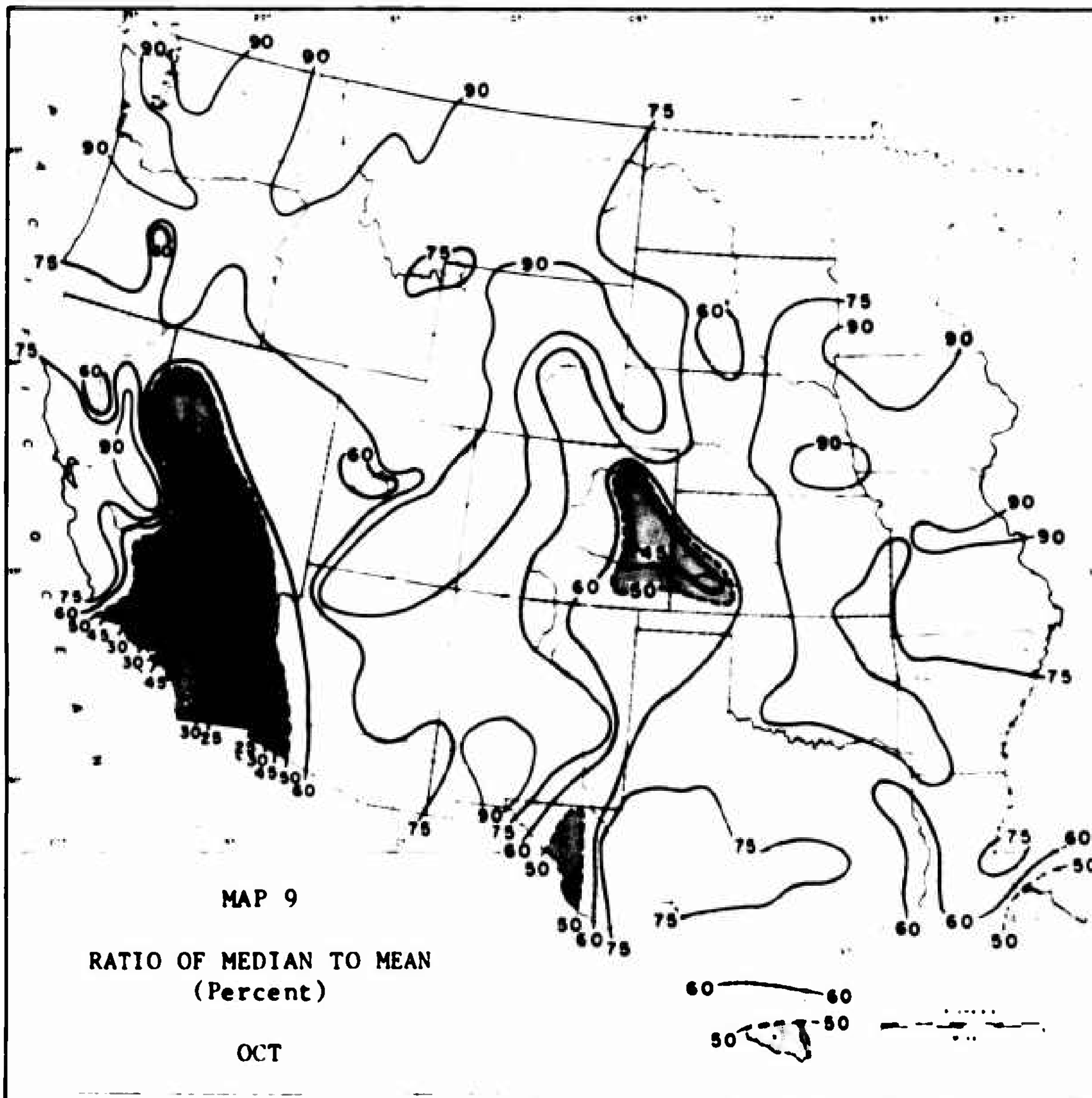
APR



MAP 8

RATIO OF MEDIAN TO MEAN
(Percent)

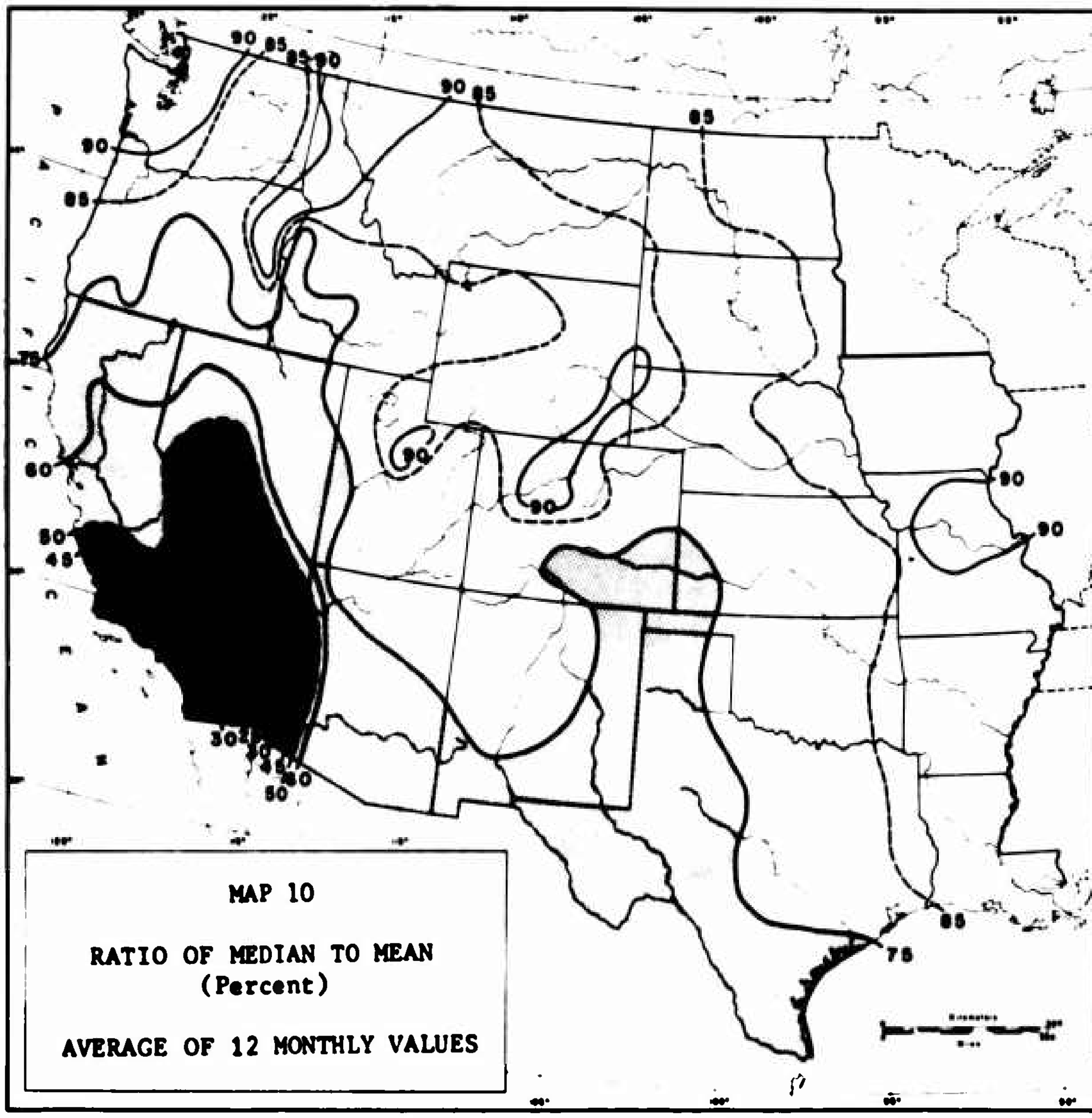
JUL



MAP 9

RATIO OF MEDIAN TO MEAN
(Percent)

OCT



MAP 10

RATIO OF MEDIAN TO MEAN
(Percent)

AVERAGE OF 12 MONTHLY VALUES

The ratios between the median and mean can also be used as excellent measures of skewness. A ratio smaller than 1 indicates a positively skewed distribution, while a ratio larger than 1 indicates a negatively skewed distribution. The greater the departure from 1, the greater the degree of skewness.

As would be expected these maps compare favorably with maps 2-5 with low values occurring in the Southwest and high values in the Northwest.

Several stations in California had no rain at all during the 30 years studied for the month of July and had to be omitted or overlooked in the drawing of isolines, since in this case the ratios would have been infinite.

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CHAPTER III

MEASURES OF DISPERSION

3.1 Absolute vs. Relative Measures of Variability

Both the mean and the median have their limitations in that they are measures of central tendency only. No single value, however determined, can hope to give a complete descriptive summary. Crowe (1933) pointed out that we require not only an index of the "normal sequence of events," but also of the "probable frequency and extent of variations from the normal."

3.2 Absolute Measures of Variability

The standard deviation is used to estimate the degree of variability about the mean and defined by the equation

$$\text{S.d.} = \left[\frac{1}{n}\sum_{i=1}^{n} (x_i - \bar{x})^2\right]^{\frac{1}{2}}$$

where n is the number of values, x_i is the individual value, and $\bar{x}$ the mean of the n values. But the standard deviation is not an appropriate term to be used with the median: while the sum of the squared deviations is least when computed about the mean, the sum of the absolute deviations is at a minimum when computed about the median. A measure of dispersion used to measure variability about the mean or median is the mean deviation, also known as the average variability (AV). The mean deviation is defined by the equation

$$\text{m.d.} = \frac{1}{n}\sum_{i=1}^{n} \left| x_i - z \right|$$

where z may be either the mean or median. The semi-interquartile range or quartile deviation q, defined by the equation

$$q = (Q_3 - Q_1)/2$$

where Q_1 and Q_3 are the first and third quartiles, is used to estimate the degree of variability about the median.

Other, but poor measures of variability, use only the highest and lowest recorded values, M and m. The range, M - m, is often used. Hellman (1909) defined the "ratio of variation" as the quotient M/m. These measures are not based on all observations, and the ratio of variation cannot be used for desert rainfall: M/m would become infinite for many stations.

3.3 Relative Measures of Variability

Absolute measures of variability are useful in helping to understand a particular set of observations, but do not give a complete picture of the variability. Thus they are of little value when comparisons between observations at several different localities are desired. This is due to the fact that variability generally increases as the values of the observations become larger. Therefore, a map showing the dispersion of observations about the mean or median at various stations using any of the measures of variability listed above, would give the same picture as a map of the means or medians of the observations themselves.

For this reason, relative measures of variability must be considered in order to derive comparable figures. The four measures of relative variability corresponding to the first four measures of variability mentioned above are given in Table 2.

Of these measures, only CV and Vr have been studied to any great extent. In studying the relative variability (Vr) of precipitation, Conrad (1941) found that a very strong mathematical dependence of the value of Vr on the yearly sum occurs when these sums are below 1000mm (39.4 inches). Because of this he concluded that the relative variability (Vr) cannot be used to compare the variability of precipitation in a locality with a small annual fall with that in another locality where the precipitation is large.

In a study of all four measures, Longley (1952) found the coefficient of variation the most satisfactory measure for comparing variability of precipitation between different stations. It was found to have small errors through sampling, in that the values of CV are comparable even when the mean precipitation values are quite different.

Longley also found that variability tends to be greater where the precipitation is least, but the relationship was not close. In a study of precipitation data at 34 stations

TABLE 2.--RELATIVE MEASURES OF VARIABILITY

The Coefficient of Variation:

$$CV = \frac{100}{\bar{x}} \sqrt{\frac{1}{n} \sum_{i=1}^{n} (x_i - \bar{x})^2}$$

The Relative Variability:

$$Vr = \frac{100}{n} \sum_{i=1}^{n} \left| \frac{x_i - \bar{x}}{z} \right|$$

and

$$VQ = \frac{100 \, (Q_3 - Q_1)}{2 \tilde{x}}$$

and, also

$$Qr = \frac{M - m}{z}$$

n is the number of values
x_i is the individual value
$\bar{x}$ is the mean
$\tilde{x}$ is the median
z is the mean or median
M is the maximum value
m is the minimum value

in British Columbia and Washington, he found the coefficient of correlation between mean precipitation and the coefficient of variability to be -0.68 for July, -0.71 for December, and -0.48 for the annual data.

3.4 Variability as Related to Rainfall Amounts

Since the majority of stations studied in this report have annual rainfall amounts below 30 inches, it is important to know the relation between Vr (and CV) or Vq and the mean or median rainfall. Conrad states that:

> ". . .the assumption that Vr represents a numerical characteristic of variability, unrelated to the arithmetic mean, has been proven fallacious by the observations. Therefore, conclusions drawn comparing values of Vr for different places in the vast regions where the annual precipitation is less than 28 inches. . . are inaccurate and misleading." (in Conrad and Pollak, 1950, p. 56)

Longley's study indicates that this may not be the case. An attempt will here be made to clarify this question and to also look at monthly relationships where the rainfall amounts are still smaller.

Figures 1, 2, and 3 were prepared to show annual and monthly relations between CV and mean rainfall, and Vq and the median rainfall. If a least fit line were fitted to each set of data, a curve would be obtained similar to the one found by Conrad when examining annual rainfall. The turning point, best seen in July, occurs at about two inches for monthly data and twenty inches for annual data.

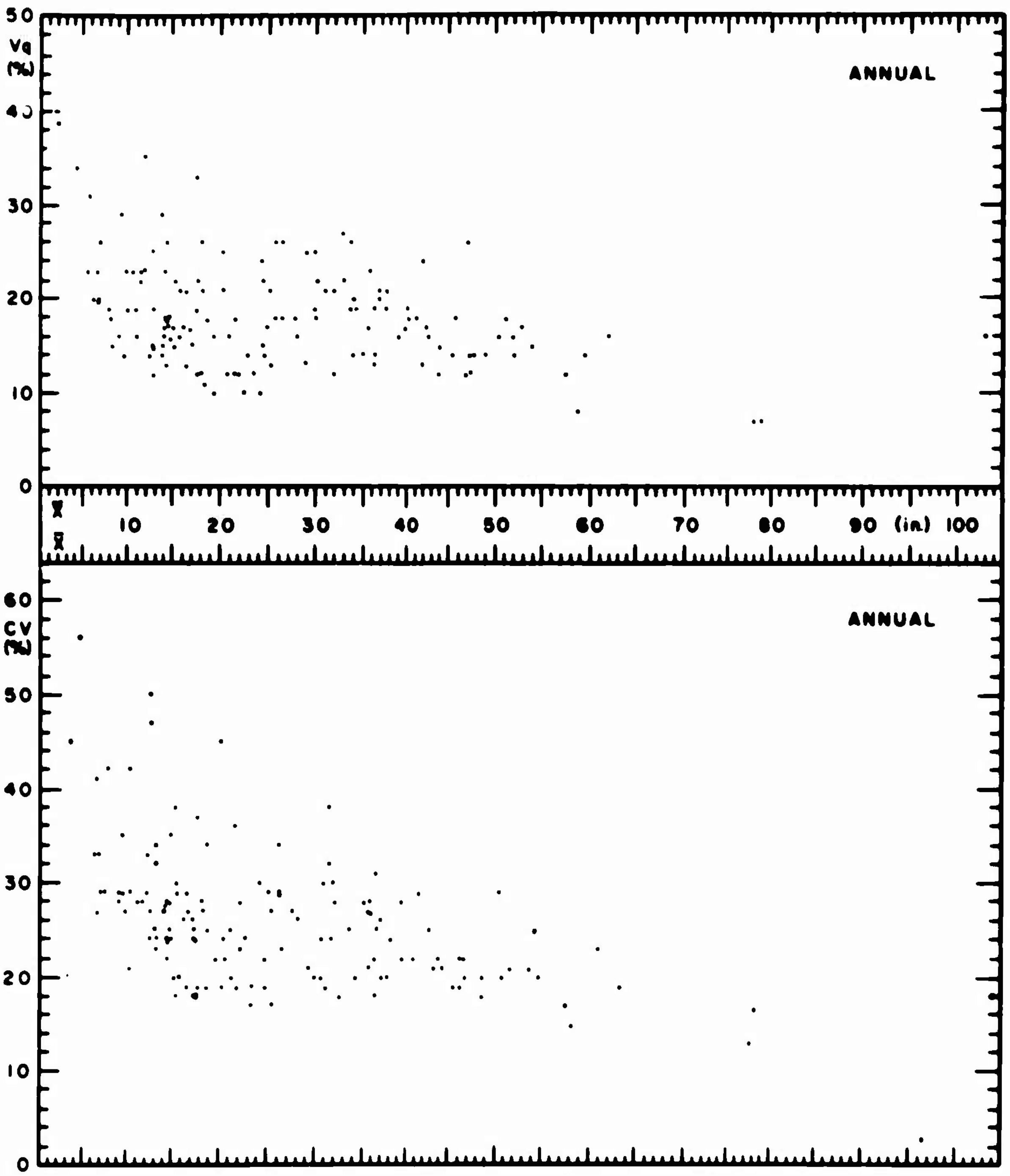


FIGURE 1.--MEASURES OF RELATIVE VARIABILITY VS. ANNUAL RAINFALL.

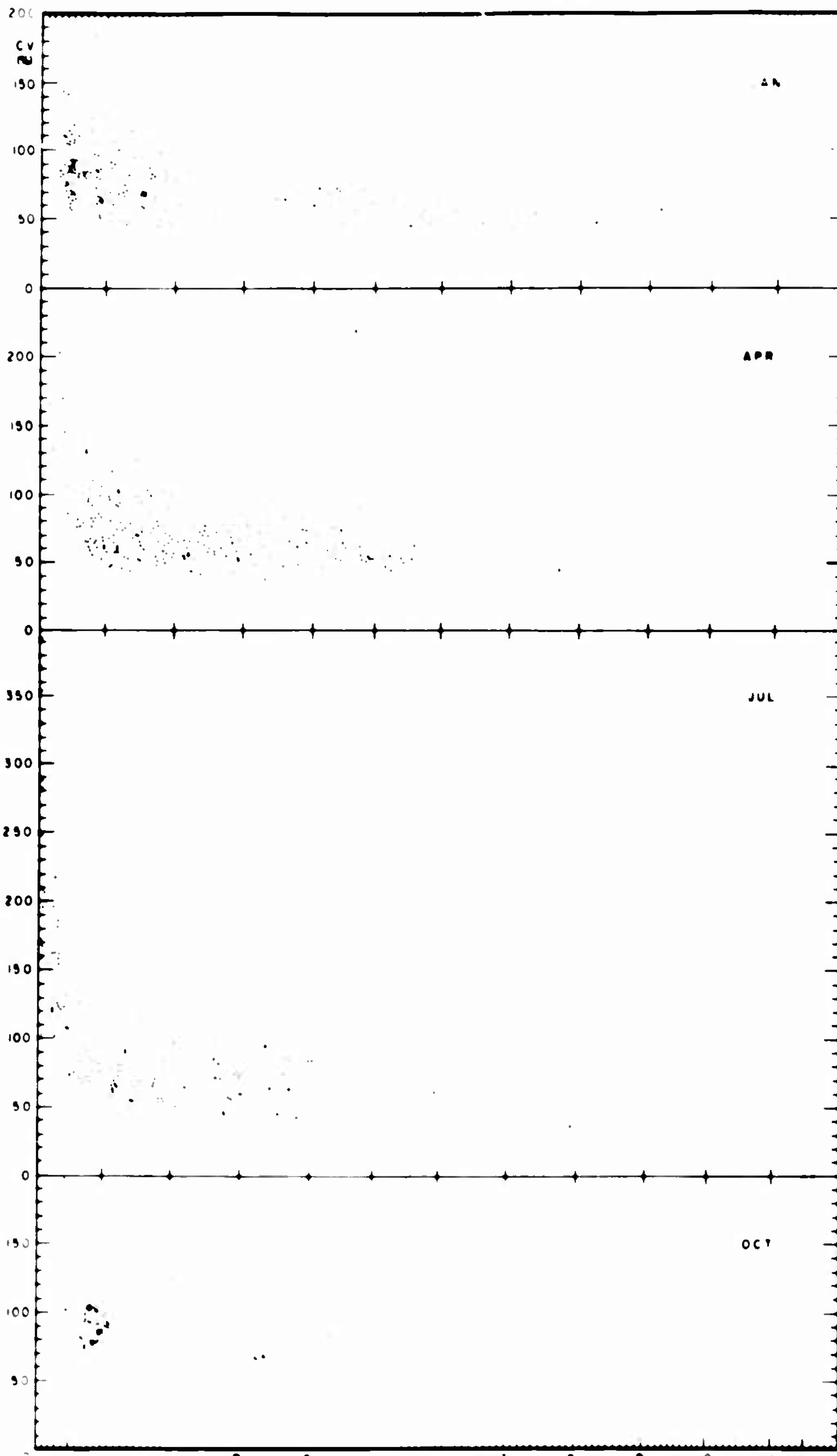


FIGURE 2.--COEFFICIENT OF VARIATION VS. MONTHLY RAINFALL.

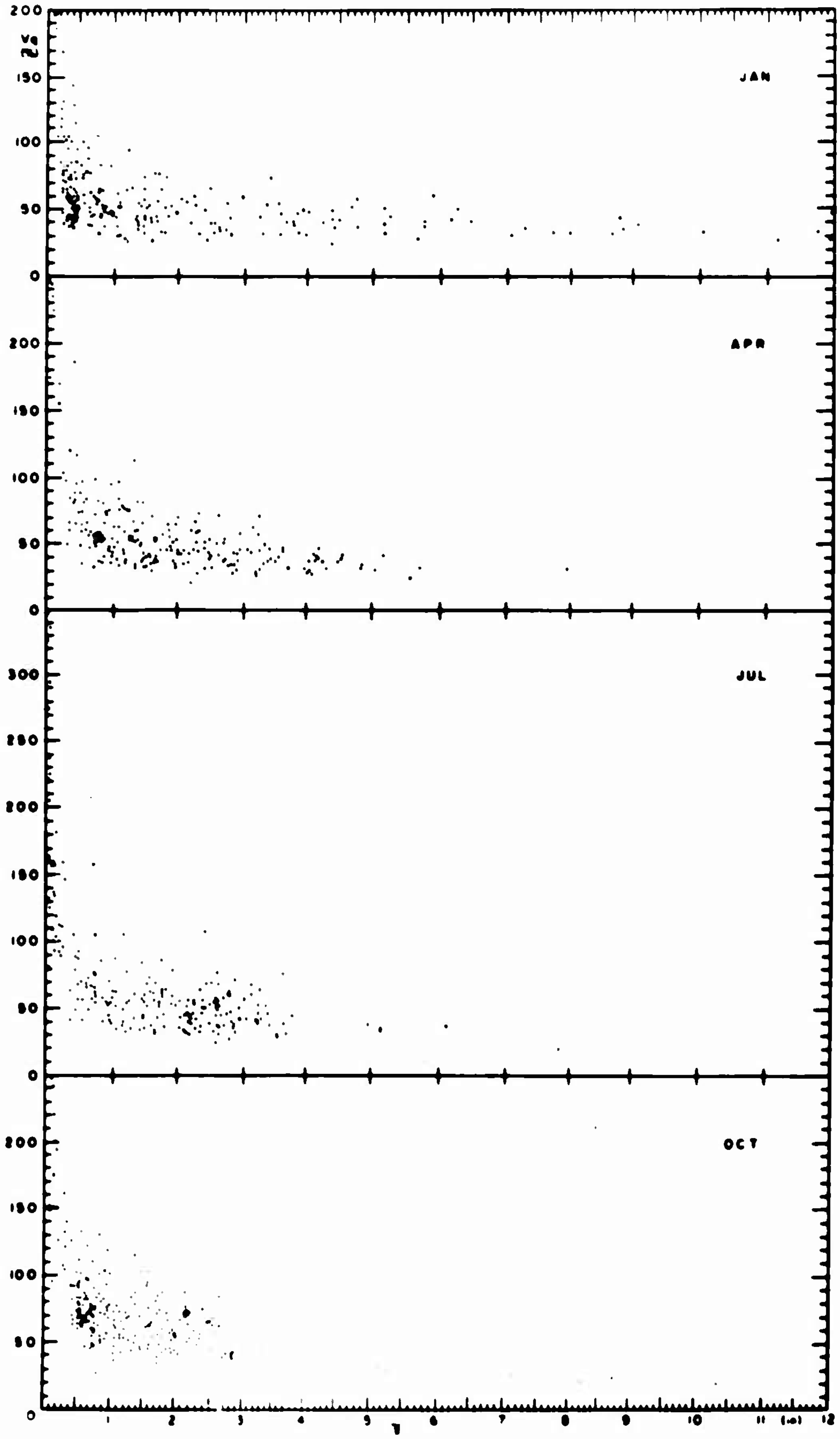


FIGURE 3.--THE RELATIVE VARIABILITY VS. MONTHLY RAINFALL.

Even though the scattering is great, at first glance it would seem as though Conrad's statement was true: at lower values there is an inverse relation between the measure of variability and the measure of central tendency. But these figures, as those by other researches, overlook several things. When performing statistical analysis on data we cannot take samples from all areas (regions) and treat them as coming from one 'population'. In the past, many studies have been made to derive generalizations about certain climatological variables. In these studies formulas were derived by looking at data from many stations scattered throughout the world. If these formulas, or generalizations, were formulated for the purpose of representing a base, and the regions determined by how they deviate from this base, this is a valid approach. But, if the purpose was to derive a generalization from which predictions could be made, the study was invalid. Generalizations formed by looking at data from dissimilar areas can be applied to the whole mass of data, but rarely to any of the "subregions".

Similar applications have been made in other areas of geography. Correlations, regression analysis, and other statistical analyses have been performed on samples supposedly from the same 'population'. In reality these samples have come from several different 'populations,' as is the case in the present analysis.

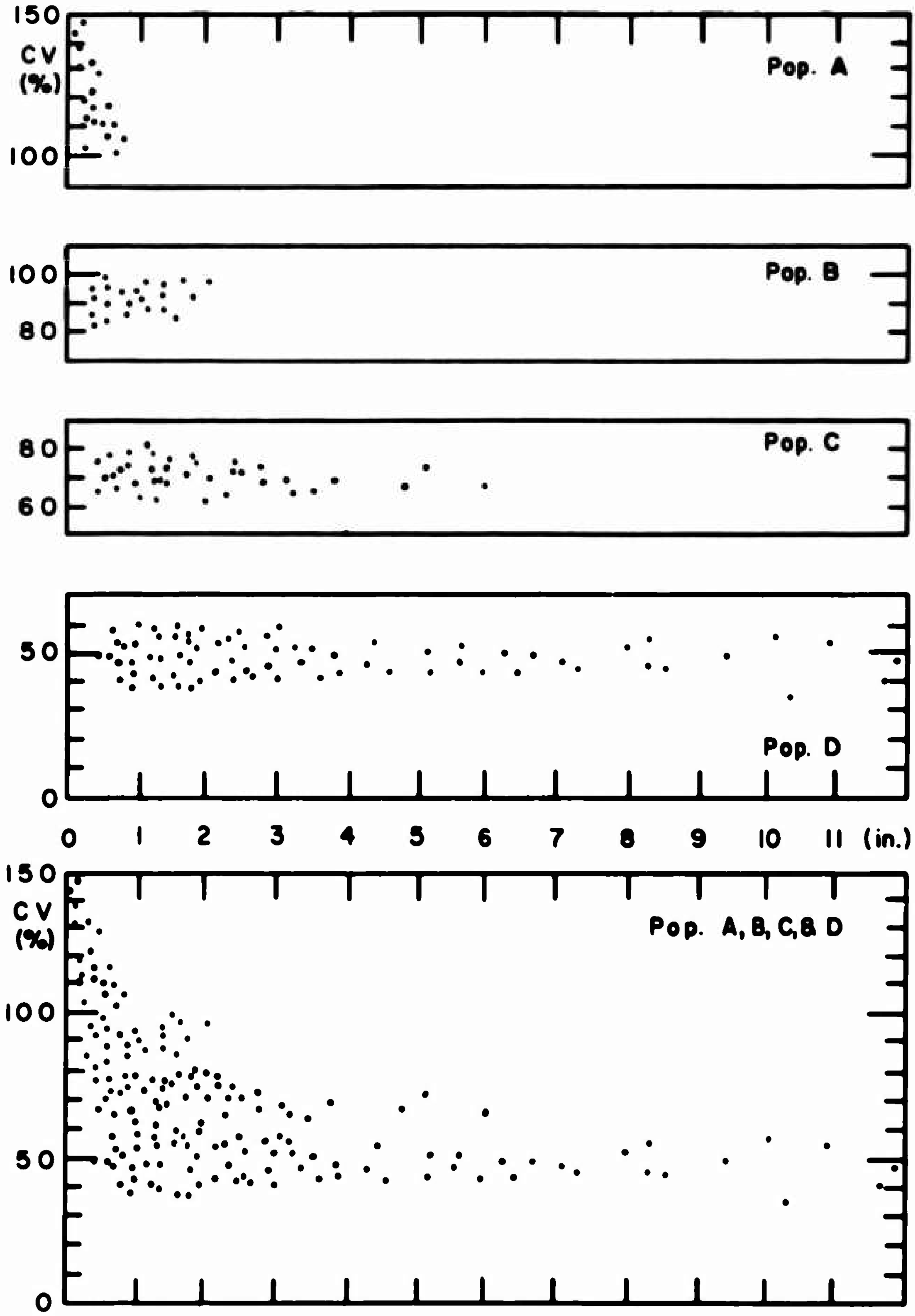
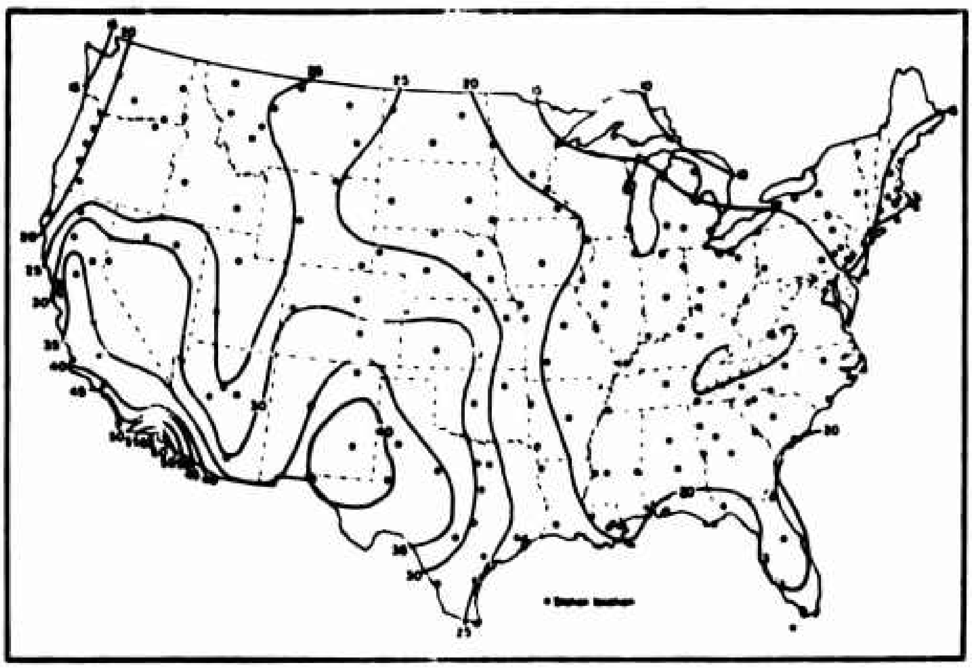


 Figure 4.--Typical Relationship of CV and Mean Rainfall.

In the majority of previous studies of CV, Vr, and Vq, data from widely scattered stations in regions with vastly different rainfall characteristics were treated as coming from the same population (or region). The results of these studies supposedly represented the behavior of these measures of relative variability for all areas. That this is hardly fact can be seen by looking at the behavior of these measures separately for several different areas. Such a study is presented in Figure 4 where the populations or subregions are represented by A, B, C, and D. The bottom graph in Figure 4 shows the typical curve obtained when data from many different populations are grouped together. It can be seen that a generalization arrived at by considering populations A, B, C, and D grouped together would not necessarily hold true for each individual population. A large inverse relation between CV and the mean rainfall occurs only with population A and this is not surprising. Any measure of relative variability would be expected to increase rapidly as the average rainfall approaches zero, since any number divided by zero is infinitely large. Although only CV is discussed in this example, the same relationships were found for Vr and Vq to varying degrees.

3.5 Variability Maps

While many maps of mean annual and mean monthly precipitation for the United States exist, few maps exist cover-



MAP 11 Coefficient of variation of annual precipitation in per cent.

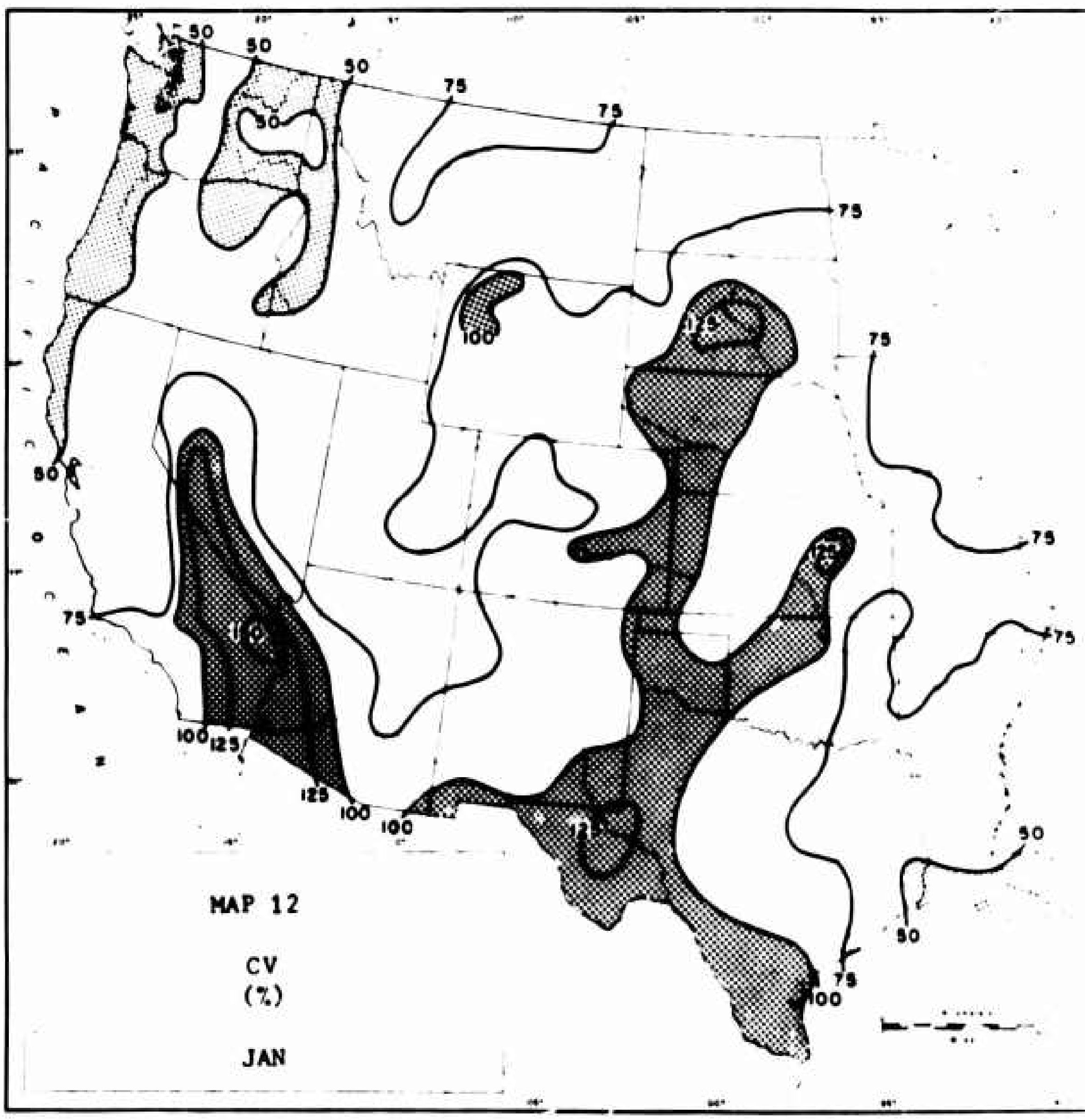
Hershfield (1962)

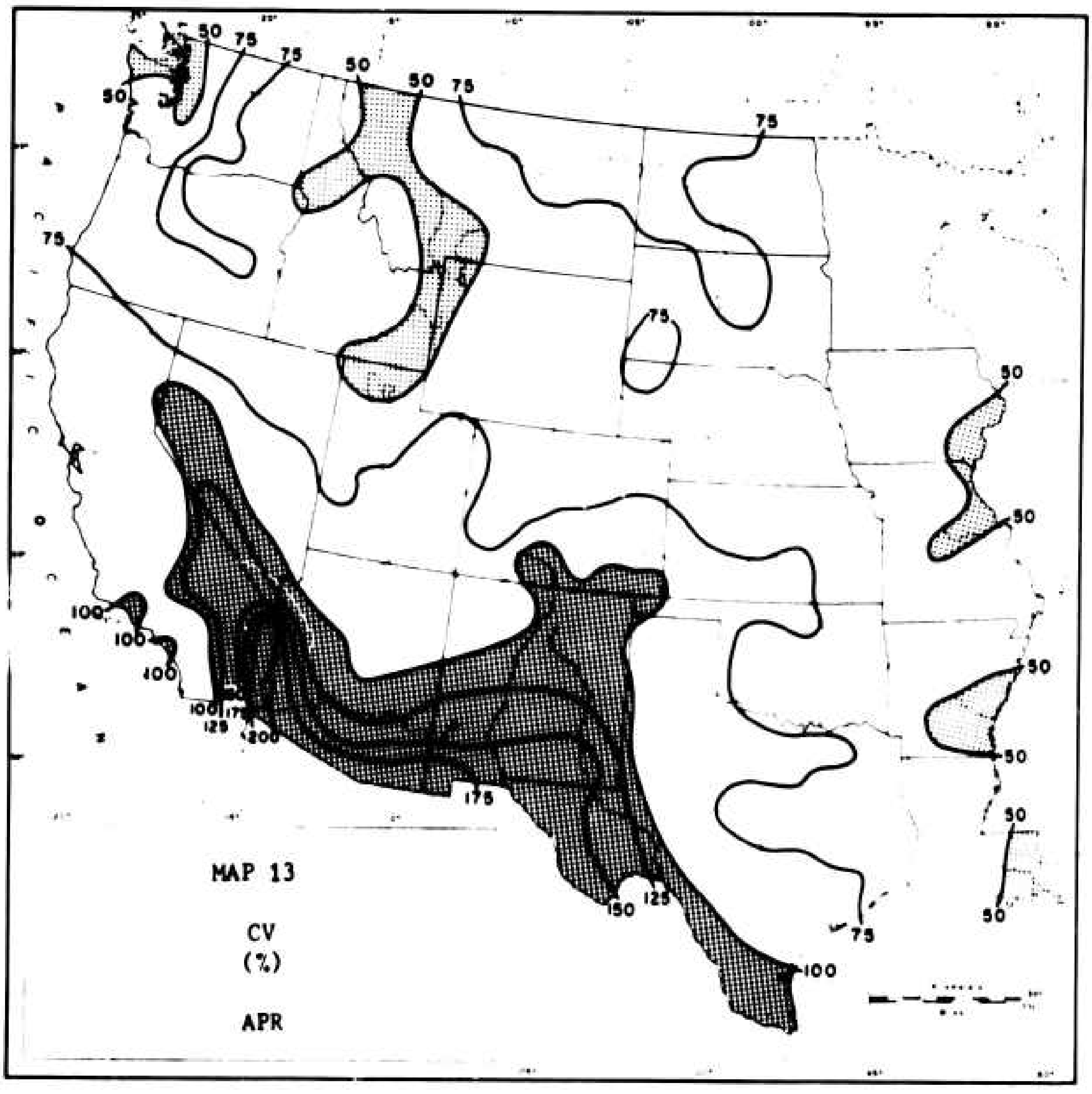
ing extended regions which show some measure of dispersion of the annual or monthly totals around their means. Two maps were uncovered showing the annual values of the coefficient of variation; the first by Hazen (1916), and the second by Hershfield (1962) (see Map 11). No maps were found showing monthly rainfall variability although the need for such maps was realized by Hershfield. Maps 12-15 showing monthly values of the coefficient of variation were prepared to partially meet this need and to show the reliability of the mean.

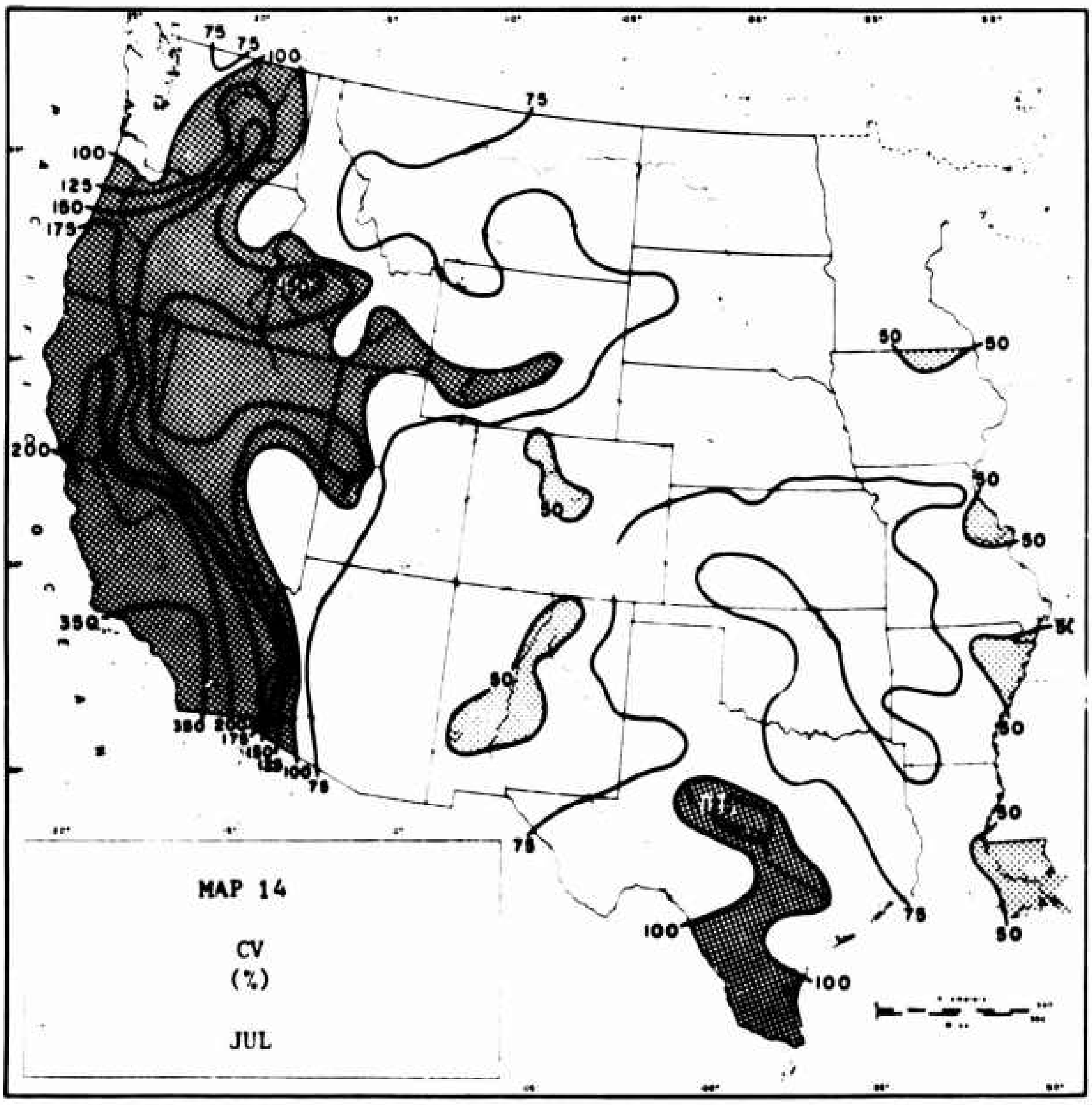
No maps were found of extended regions showing the dispersion of values about the median. While the coefficient of variation is a suitable term to use in measuring the dispersion around the mean, a good index of variability around the median is obtained by expressing the quartile deviation as a percentage of the median. Maps 16-19 were prepared using values determined in this manner.

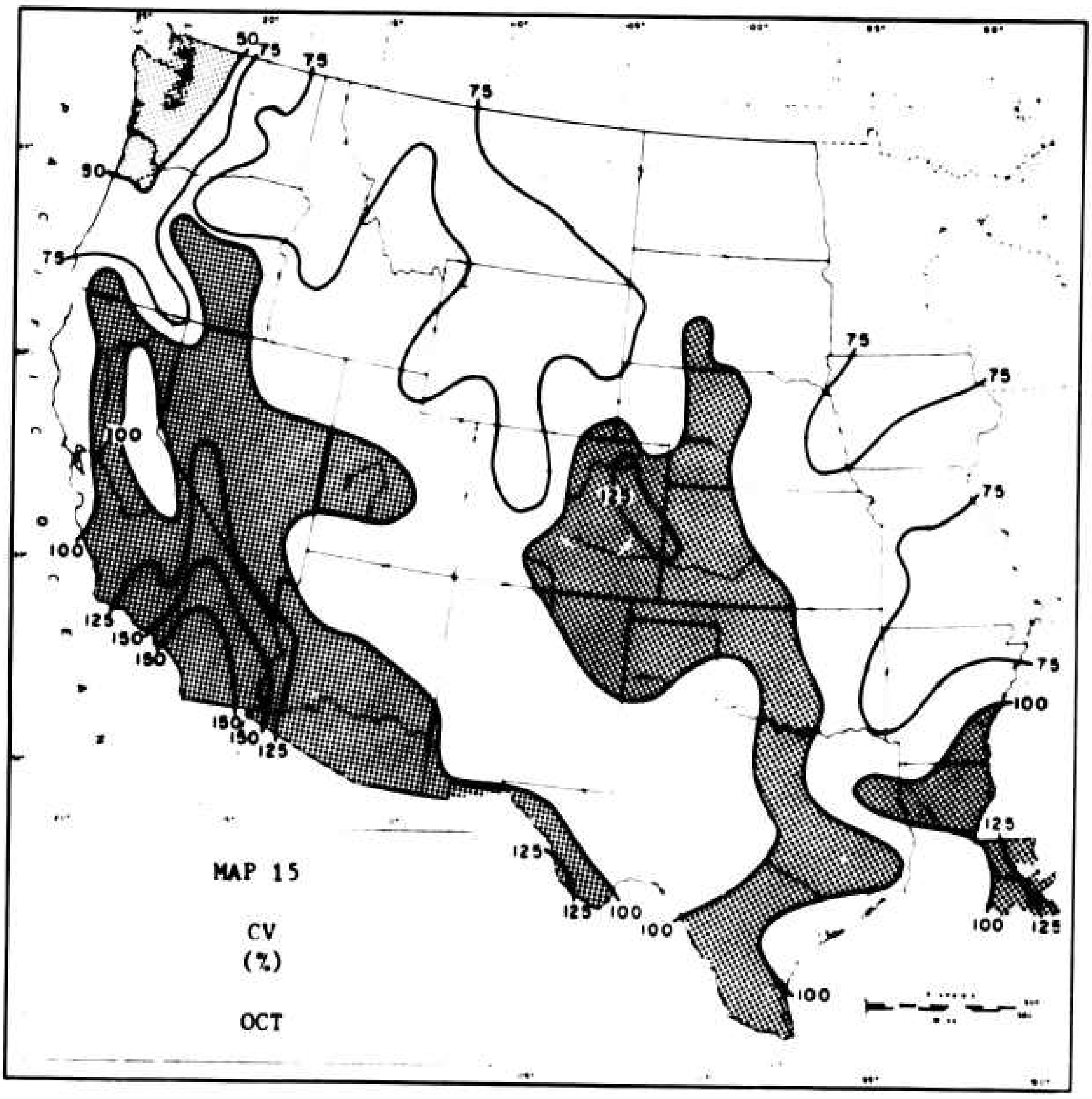
3.6 A Note on the Coefficient of Variation

The coefficient of variation (CV) becomes meaningless in terms of normal probability theory when it becomes larger than 1.00 since the standard deviation of a normally distributed variable cannot be larger than the mean. But, if CV is looked at as a measure of dispersal divided by a measure of central tendency, without reference to the type of distribution, it becomes very useful.

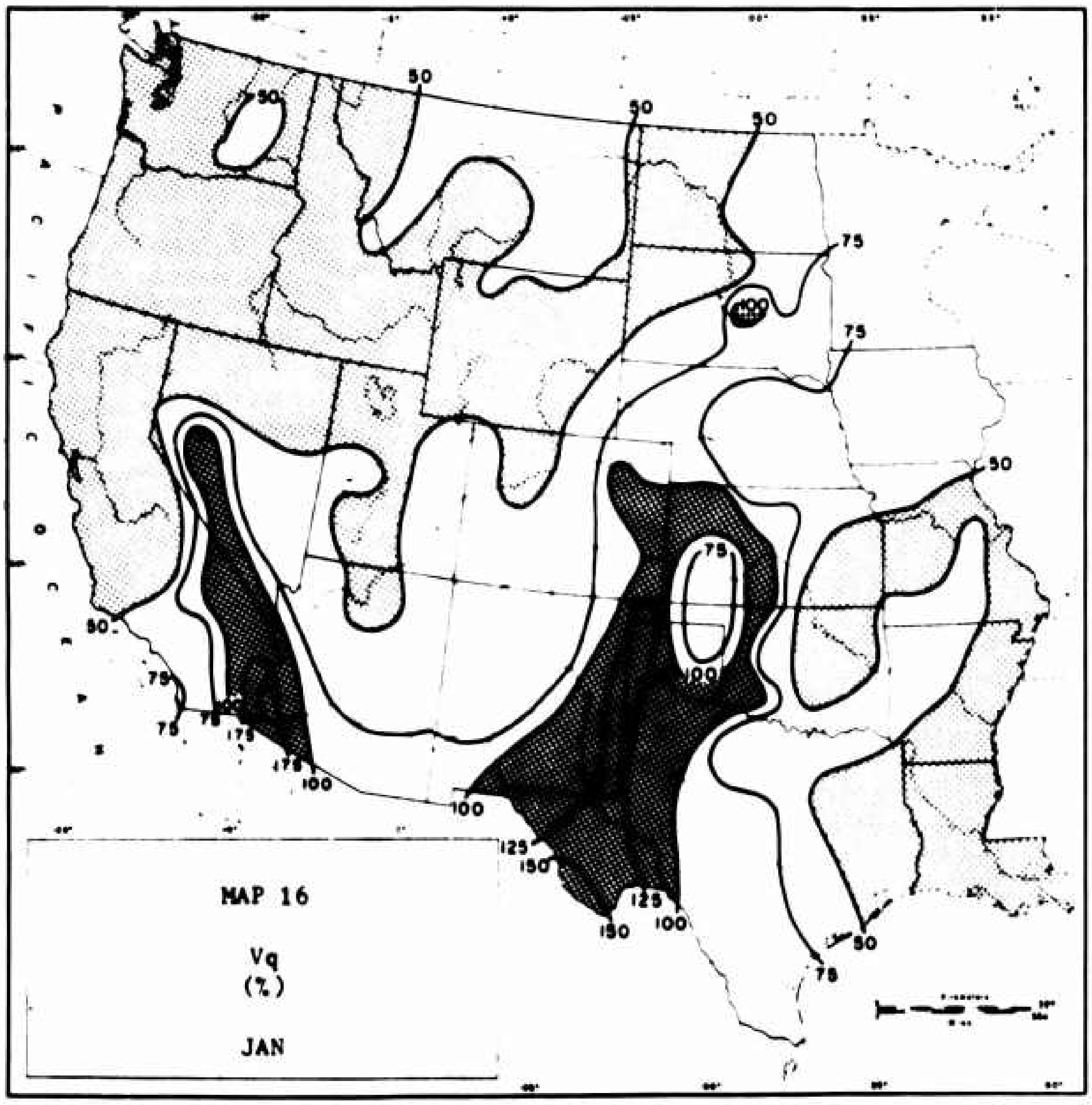

MAP 12
CV
(%)
JAN
50
75
100
125

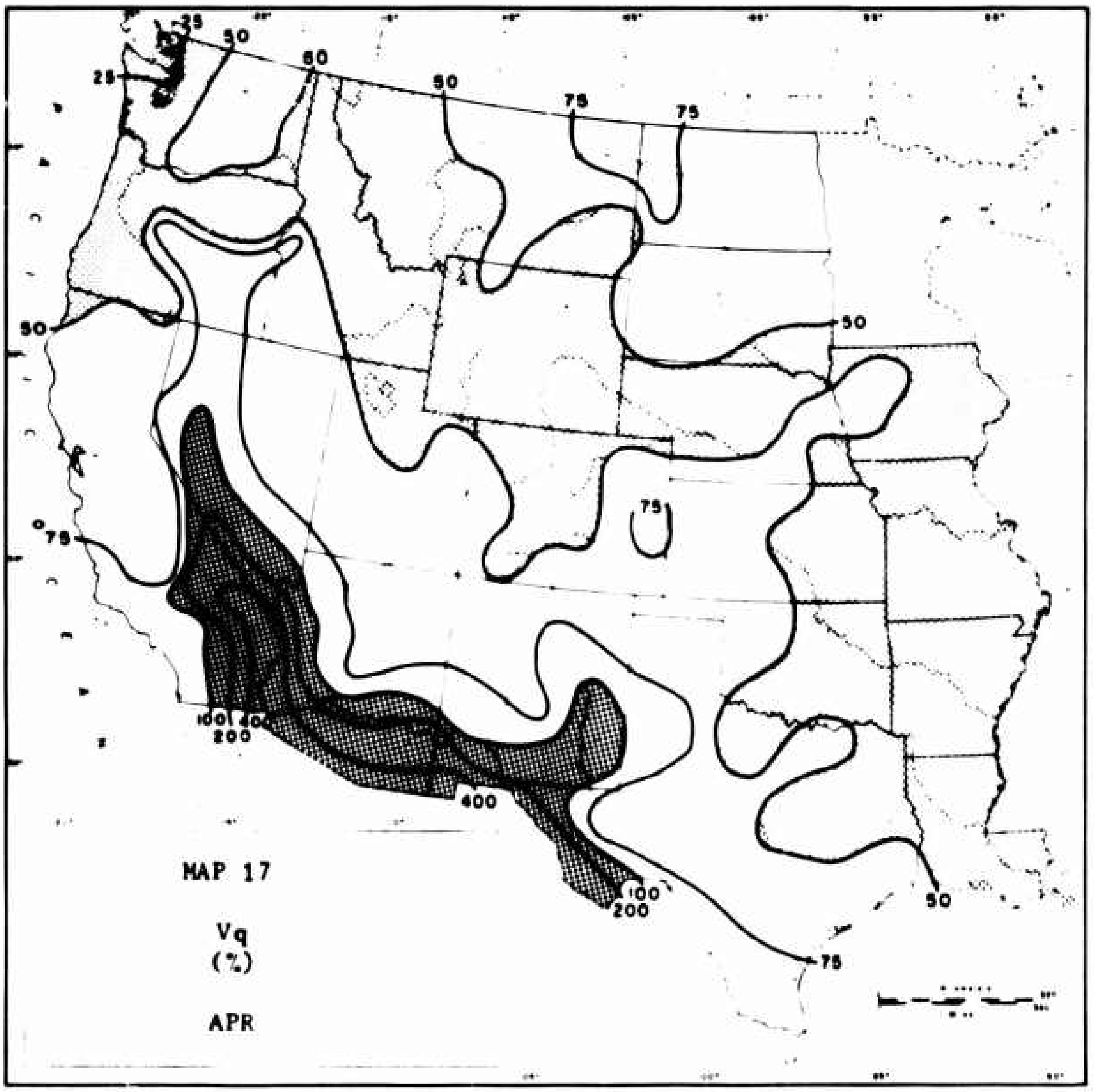

50
75
100
125
150
175
200
MAP 13
CV
(%)
APR

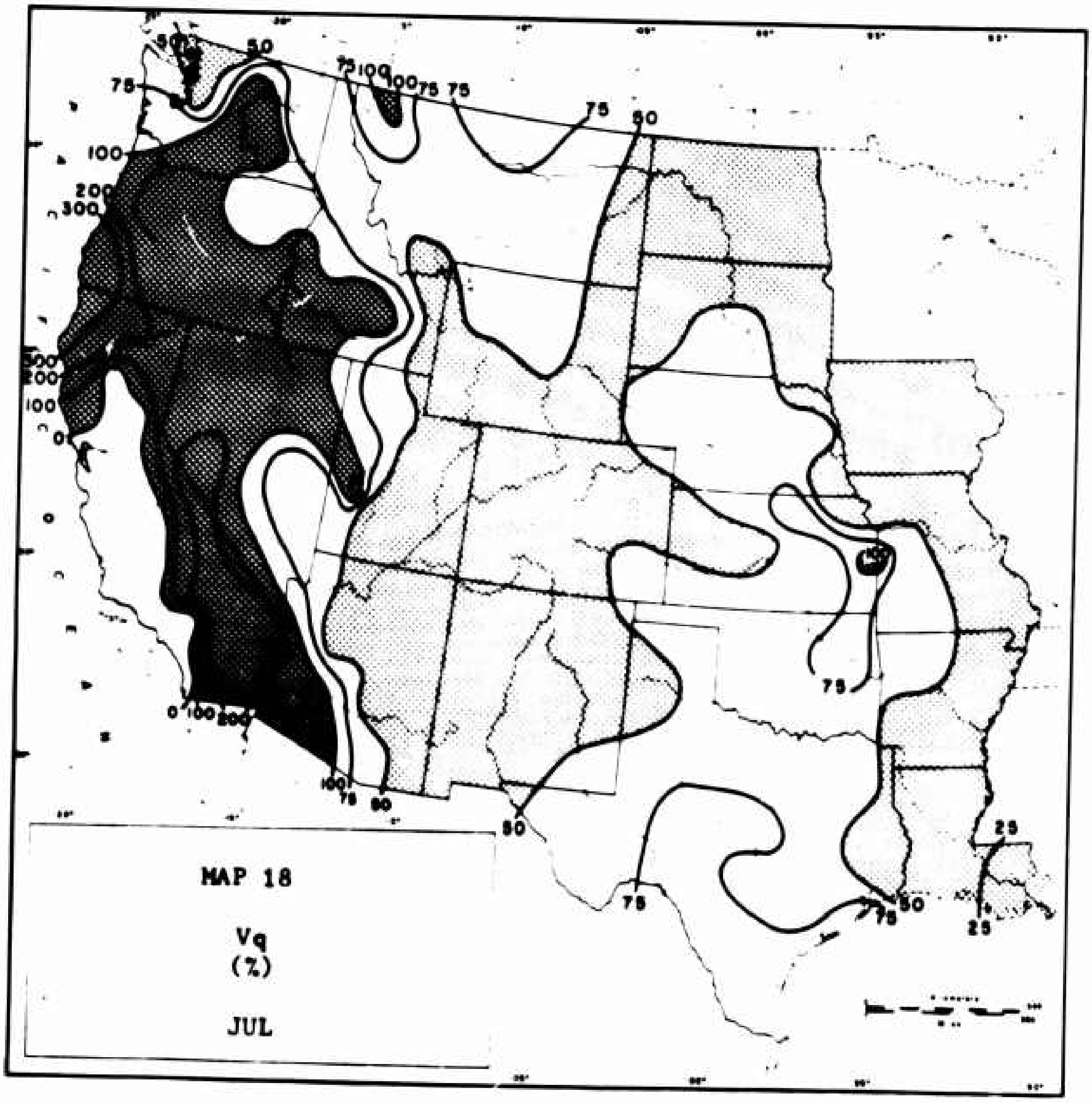

MAP 14
CV
(%)
JUL

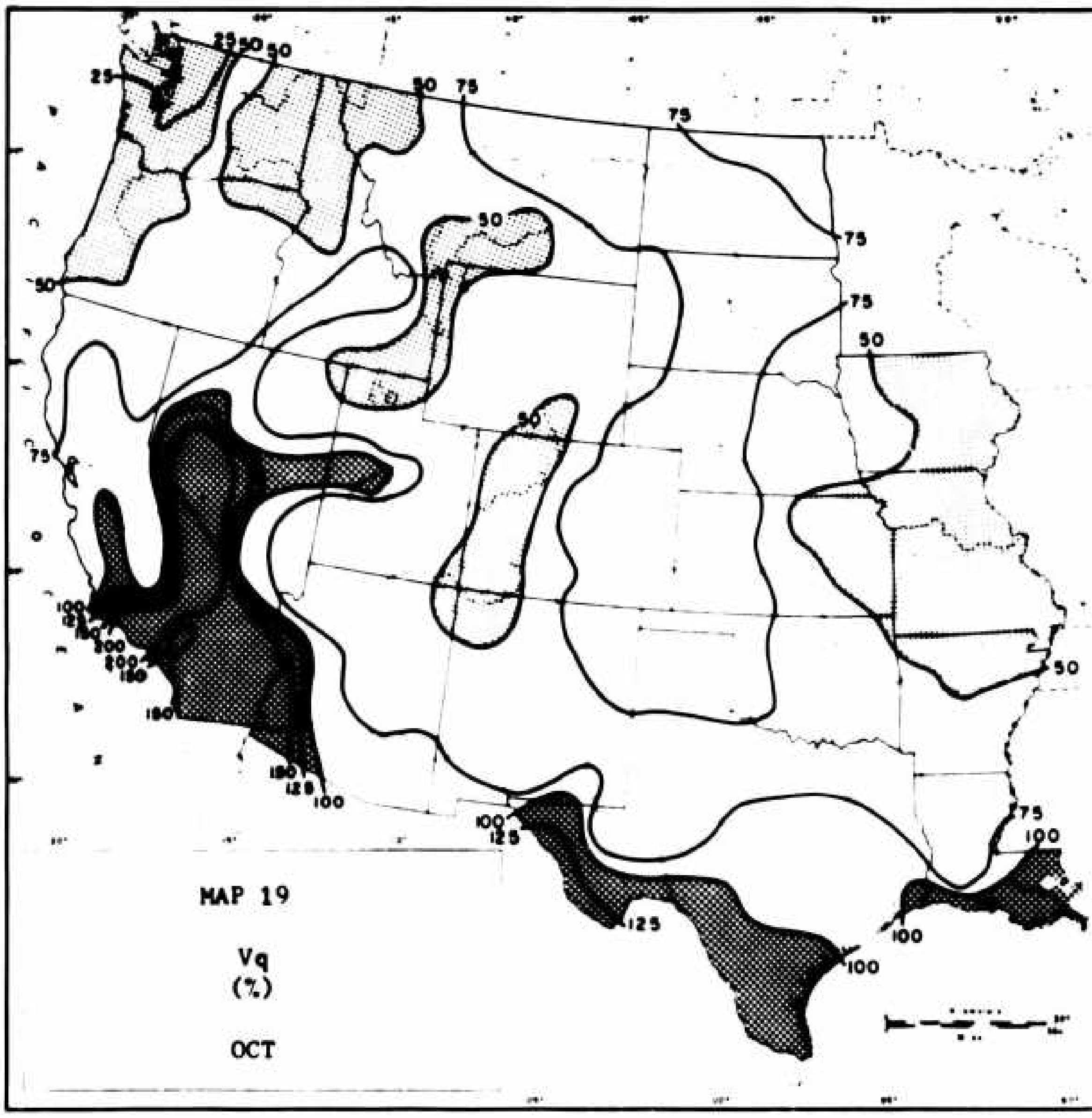


50
75
75
75
50
75
100
100
125
150
150
150
150
125
125
75
75
75
75
100
125
125
125
100
100
100
100
125
MAP 15
CV
(%)
OCT


MAP 16
Vq
(%)
JAN
50
75
100
125
150
175


25
50
60
50
75
75
25
50
50
75
75
100
400
200
400
100
200
50
75
MAP 17
Vq
(%)
APR


MAP 18
Vq
(%)
JUL
50
75
100
200
300
0
25


MAP 19
Vq
(%)
OCT

Hastings (1965) suggests that CV can be used for climatological and ecological classifications, and as an indicator of rainfall probability. If seasons are ranked, the one with the lowest coefficient being 1 and the highest 4; the rank-sequence can be used to delineate regions. Such a classification reflects accurately the relative value of moisture in that it takes into account not only seasonal variability and amount of rainfall, but also the reliability of the amount.

The coefficient of variation is also a measure of skewness. Where CV exceeds 0.5 (50%) skewing sets in. When CV exceeds 1.00 (100%) non-normality increases rapidly.

CHAPTER IV

CLIMATIC PREDICTION

4.1 Normals

In previous chapters the question of what statistic best represents the 'normal' was investigated. In this chapter the length of record upon which to base the normal will be examined.

As mentioned earlier, one of the prime uses of the normal is as a predictor of future events. At present, climatic normals are based on 30 years of record. Many studies (as summarized by Court, 1967) show this may not be the optimum length of record. In these studies, means of varying lengths of record were used in determining the optimum length of record. No attempt has yet been found to use the median in relation to this question. In the present study, the median of varying lengths of record will be used as the predictor of future events and the results compared with those obtained through the use of the mean.

4.2 Procedures

One of the most generally used procedures for determining the optimum length of record is to calculate the averages of the squared differences between the means of varying numbers of observations and the values being predicted. Using the notation adopted by Court (1967) this extrapolation variance, S^2_{km}, is computed as

$$S^2_{km} = \frac{1}{n-k-m+1} \sum_{i=1}^{n-k-m+1} \left[x_{i+k+m-1} - \frac{1}{k} \sum_{j=0}^{k-1} x_{1+j} \right]^2 \quad (1)$$

where k is the number of antecedent observations from which a mean (or median) is computed; m is the lag between the k year period and the value being estimated; and n the number of observations x_i ordered in time from x_1 to x_n.

In the present study this equation was modified to give D_{km}, the average of the absolute differences between the medians ($\tilde{x}$) of k years and the values being estimated, as

$$D_{km} = \frac{1}{n-k-m+1} \sum_{i=1}^{n-k-m+1} \left| x_{1+k+m-1} - \tilde{x}_{k,i} \right| \quad (2)$$

where $\tilde{x}_{k,i}$ represents the median of k years beginning with the observation x_i.

Since S_{km} and D_{km} are not comparable (the first being an average of squared differences and the second being an average of absolute differences), a third value, Q_{km}, the mean prediction error, was calculated as

$$Q_{km} = \frac{1}{n-k-m+1} \sum_{i=1}^{n-k-m+1} \left| x_{i+k+m-1} - \frac{1}{k} \sum_{j=0}^{k-1} x_{i+j} \right| \quad (3)$$

As Q_{km} represents the average of absolute differences between the means of k years and the values being estimated, it is directly comparable to D_{km}.

Appendix II contains a program which computes the three above values and places a star after the lowest value. The length of record at which the lowest value occurs will be hereafter referred to as k*. The program also computes the percentage difference between the values obtained for S^2_{km}, D_{km}, and Q_{km} at k*, the optimum length of record, and those obtained at the other values of k.

Although the program computes all values of S_{km} and Q_{km} for k years from 1 to 50, only odd values of k from 3 to 49 were used in the computation of D_{km} in order to keep the program relatively simple. For this reason, and in order to keep everything as comparable as possible, only the values of S^2_{km}, D_{km}, and Q_{km} obtained for odd values of k will be considered in most of the following discussions.

4.3 Random Numbers

S^2_{km} has been shown by Court (1967) to decrease as 1 + 1/k, and the graphs appearing in his report bear this line as a guide to determine the significance of the calculated values of S^2_k. Since S^2_k is no longer the only value being examined, it would be of interest to see how these lines compare with those for Q_k and D_k (m no longer appears as a subscript since only the values for m=1 are being used.) To do this, equations (1), (2), and (3) were used to compute S^2_k, Q_k, and D_k for 1000 random normal numbers (mean zero, variance unity). Values were also obtained by

TABLE 3.--OPTIMUM LENGTH OF RECORD (k*)--PRECIPITATION[1]

STATION	JAN			FEB			MAR			APR			MAY			JUN		
	S_k^2	Q_k	D_k	S_k^2	Q_k	D_k	S_k^2	Q_k	D_k	S_k^2	Q_k	D_k	S_k^2	Q_k	D_k	S_k^2	Q_k	D_k
Ft. Ross	49	49	49	49	49	49	49	49	49	13	35	31	49	49	45	47	47	45
Ft. Collins	9	9	7	49	49	49	43	43	43	39	45	41	49	49	49	37	37	37
Dodge City	27	31	25	49	49	49	19	23	21	27	27	27	25	25	25	45	45	45
Vicksburg	31	31	31	37	35	35	47	47	47	49	49	49	47	47	49	31	31	31
Memphis	15	11	13	35	35	33	49	49	49	17	19	17	27	27	25	29	43	43
Cairo	15	17	11	27	25	19	15	15	27	47	47	47	27	27	27	13	13	13
Madison	37	43	49	31	31	33	47	47	47	43	45	43	29	47	47	27	27	29
Pittsburgh	17	43	43	39	41	37	9	9	49	17	41	41	19	19	19	23	43	23
Lynchburg	27	27	27	47	47	37	45	47	47	47	45	47	49	49	49	37	7	39

STATION	JUL			AUG			SEP			OCT			NOV			DEC			YR		
	S_k^2	Q_k	D_k	S_k^2	Q_k	D_k	S_k^2	Q_k	D_k	S_k^2	Q_k	D_k	S_k^2	Q_k	D_k	S_k^2	Q_k	D_k	S_k^2	Q_k	D_k
Ft. Ross	49	49	45	11	11	7	37	37	49	31	31	49	45	45	45	41	41	41			
Ft. Collins	45	13	47	13	7	15	17	17	33	17	39	17	39	43	45	27	27	41			
Dodge City	43	43	43	45	45	45	41	41	41	25	25	25	39	41	41	45	45	47	43	43	43
Vicksburg	25	15	23	17	21	21	43	43	43	49	49	49	17	17	13	43	43	41	27	33	17
Memphis	31	33	35	45	45	45	49	49	49	15	15	13	49	49	49	33	33	33	47	47	49
Cairo	23	27	31	11	29	27	27	27	27	39	49	49	11	9	21	19	25	23	17	25	23
Madison	47	47	47	43	39	39	15	15	13	41	41	23	13	11	13	49	49	49	47	47	49
Pittsburgh	41	41	43	23	23	25	15	17	17	19	27	5	19	19	23	21	21	31	31	31	33
Lynchburg	45	31	27	31	33	35	25	25	25	39	39	39	19	19	23	35	49	37	5	5	47

biasing this sample, as in Court's study, in mean and in variance as depicted on the bottom of Figures 5-10.

The main difference between the three measures is the rate of change as k becomes larger. S_k^2 shows the greatest amount of variance while Q_k shows the least. There can be seen no significant difference between Q_k and D_k when values of k are above 15. With biasing, all three behave in the same manner and a detailed discussion of the possible significance of this behavior is given in Court's paper.

4.4 Analysis

For purposes of comparison, the seven stations for which S_{km}^2 values have already been determined in Court's study (1968), along with Fort Collins and Fort Ross were chosen for study. The latter two stations were included so that data from drier regions might also be studied. Locations for these stations along with the number of years of record are given in Map 20.

In a preliminary study Q_k and D_k were computed for the above stations and the values of k* listed, along with those for S_k^2, in Table 3. Examination of this Table shows that no method of computation is consistently better than another, and that in the majority of cases, k* values are identical. It seems obvious that such an approach is unsatisfactory for the purpose of determining the advantages of the mean or median.

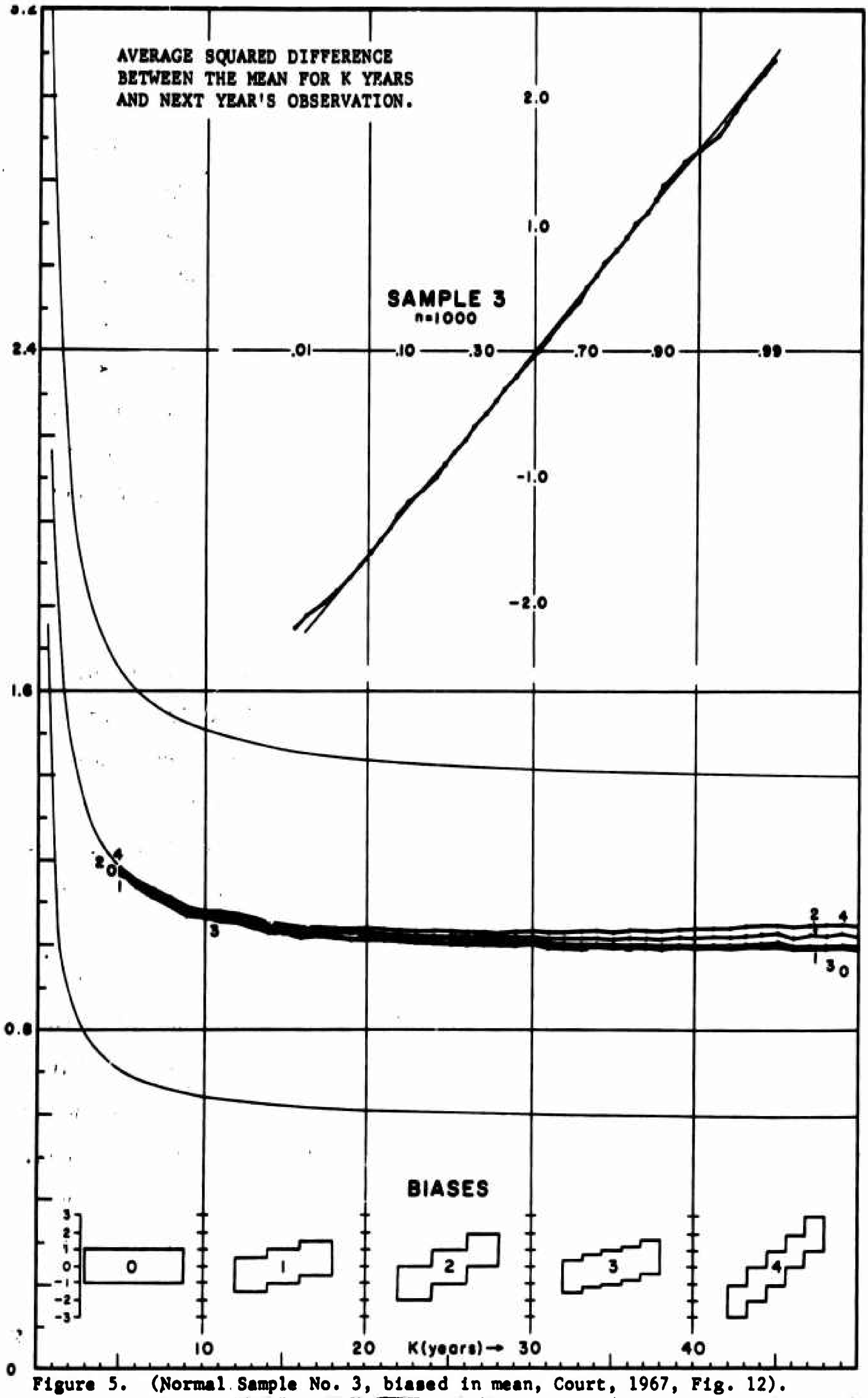


Figure 5. (Normal Sample No. 3, biased in mean, Court, 1967, Fig. 12).

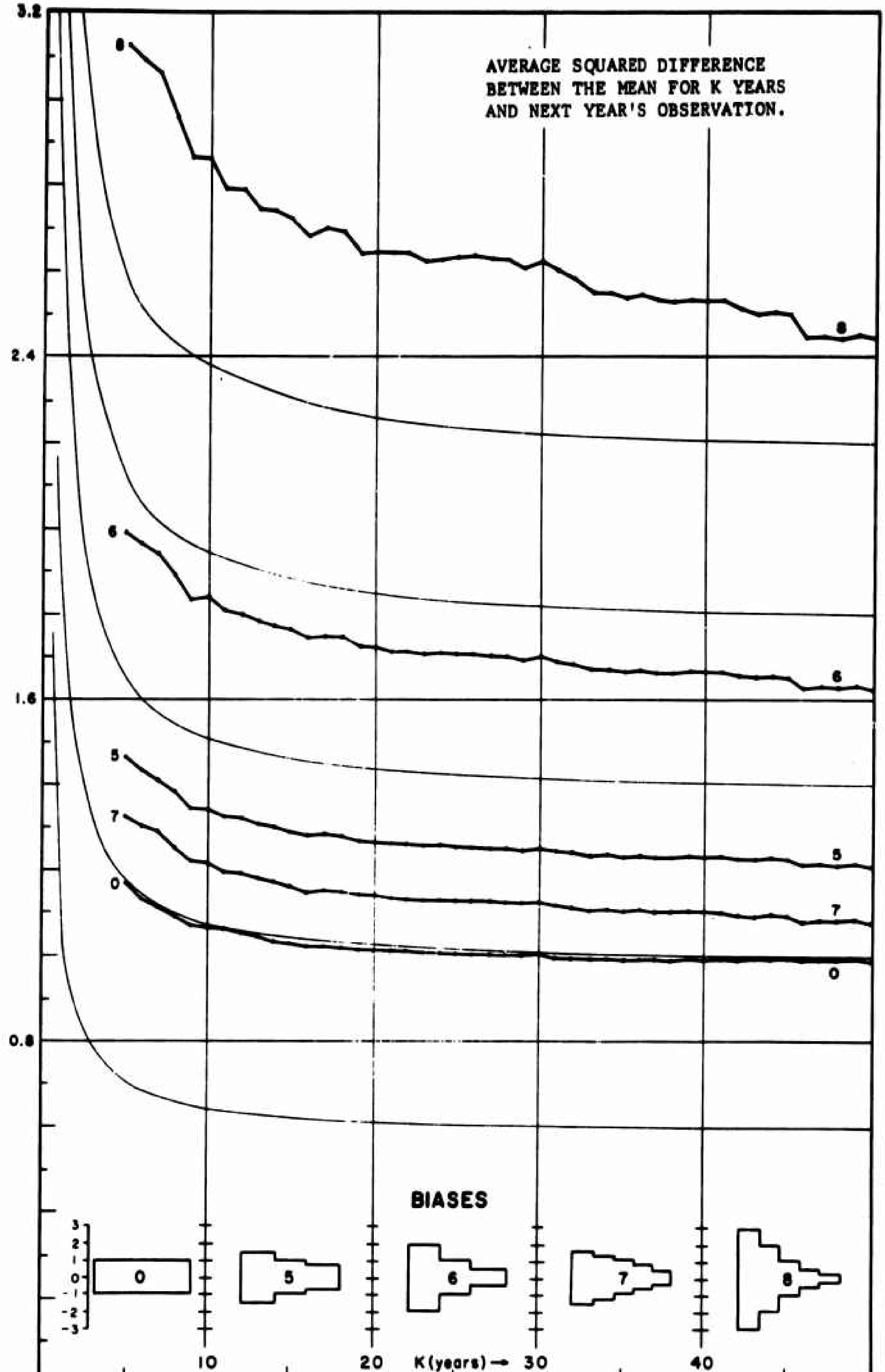
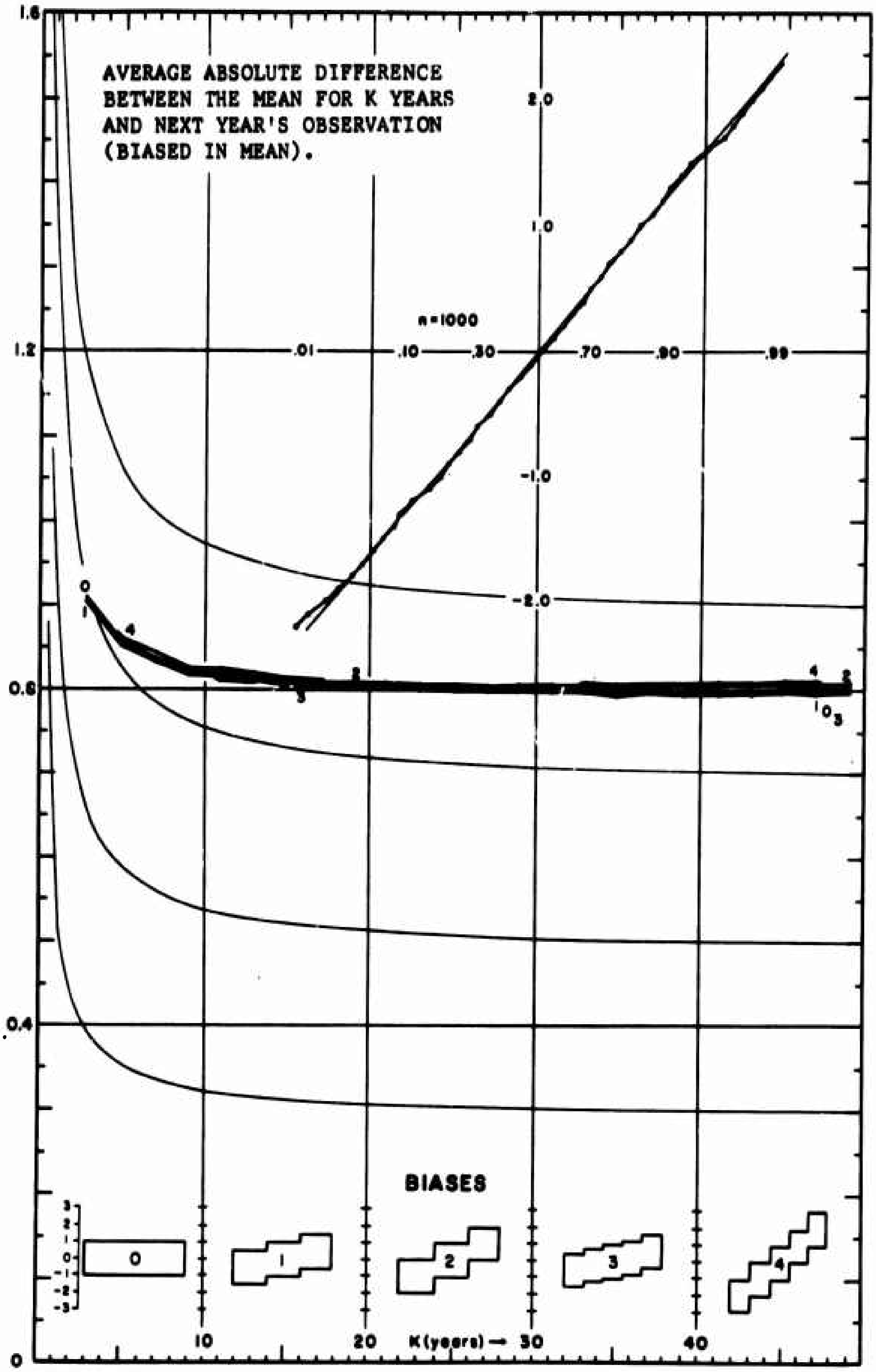


Figure 6. (Normal Sample No. 3, biased in variance, Court, 1967, Fig. 13).



AVERAGE ABSOLUTE DIFFERENCE
BETWEEN THE MEAN FOR K YEARS
AND NEXT YEAR'S OBSERVATION
(BIASED IN MEAN).
n=1000
.01
.10
.30
.70
.90
.99
2.0
1.0
-1.0
-2.0
1.6
1.2
0.8
0.4
0
BIASES
10
20
K(years) →
30
40

FIGURE 7.

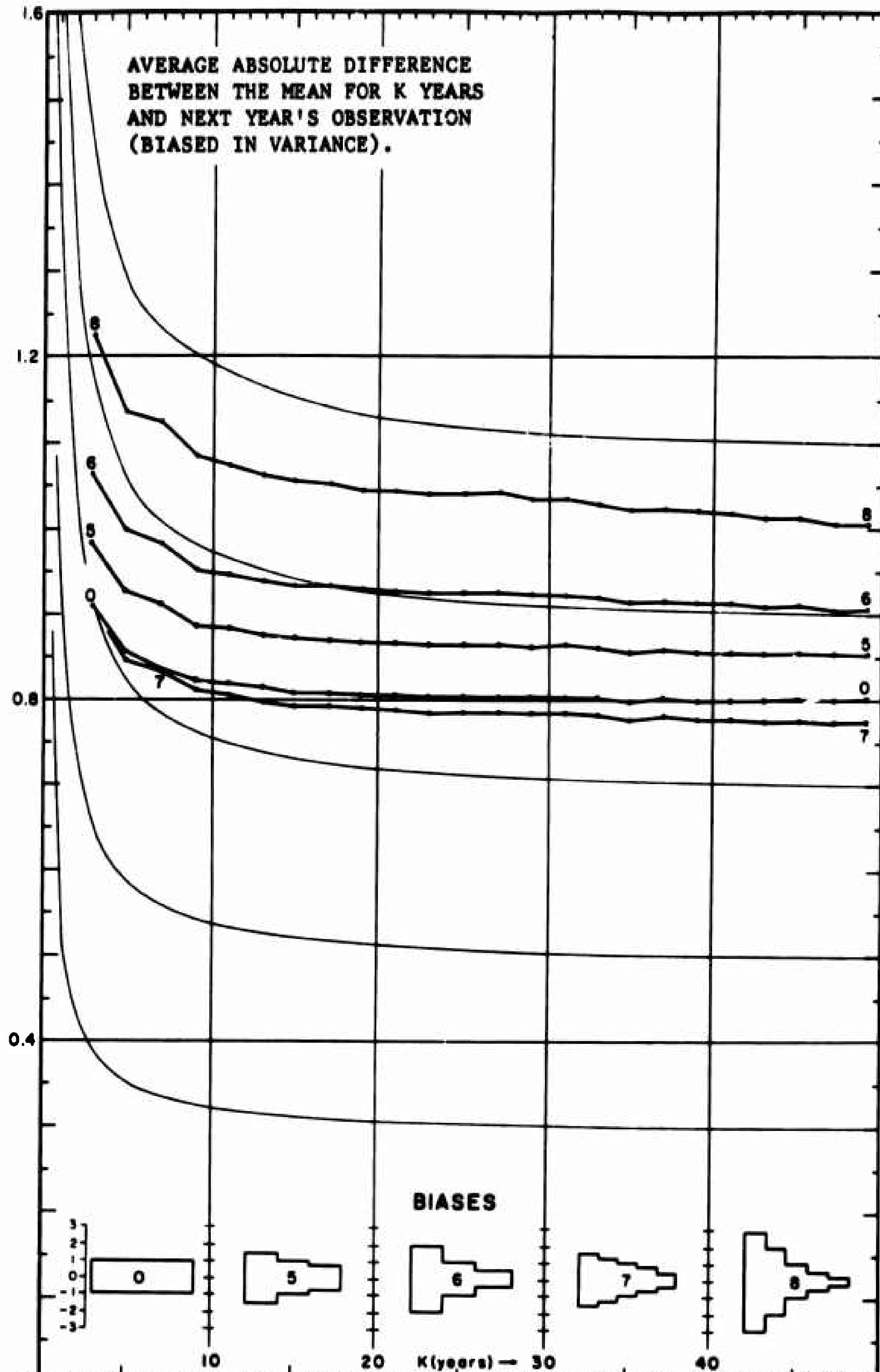

AVERAGE ABSOLUTE DIFFERENCE BETWEEN THE MEAN FOR K YEARS AND NEXT YEAR'S OBSERVATION (BIASED IN VARIANCE).
1.6
1.2
0.8
0.4
0
8
6
5
0
7
BIASES
10
20
K(years) →
30
40

FIGURE 8

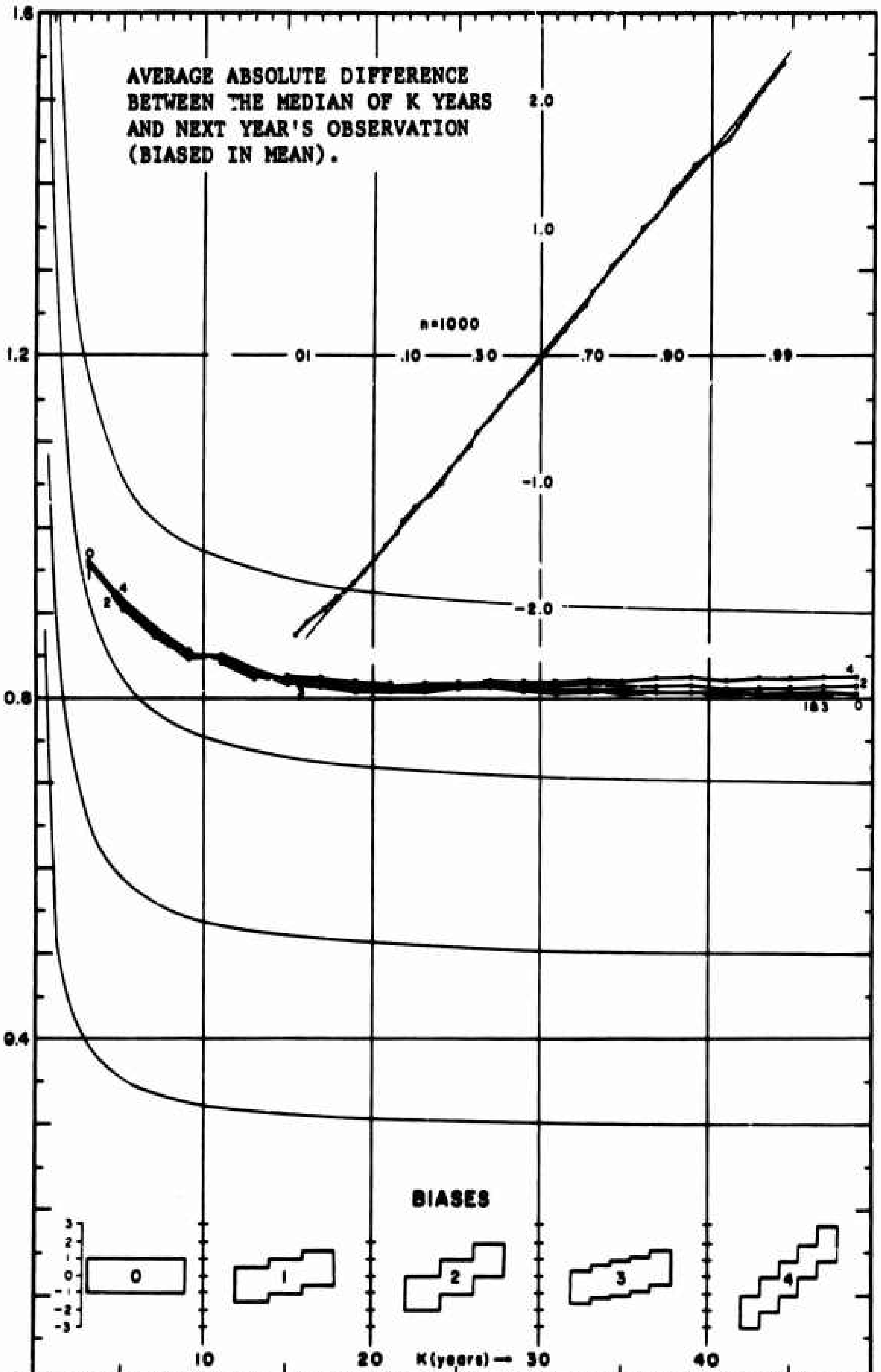
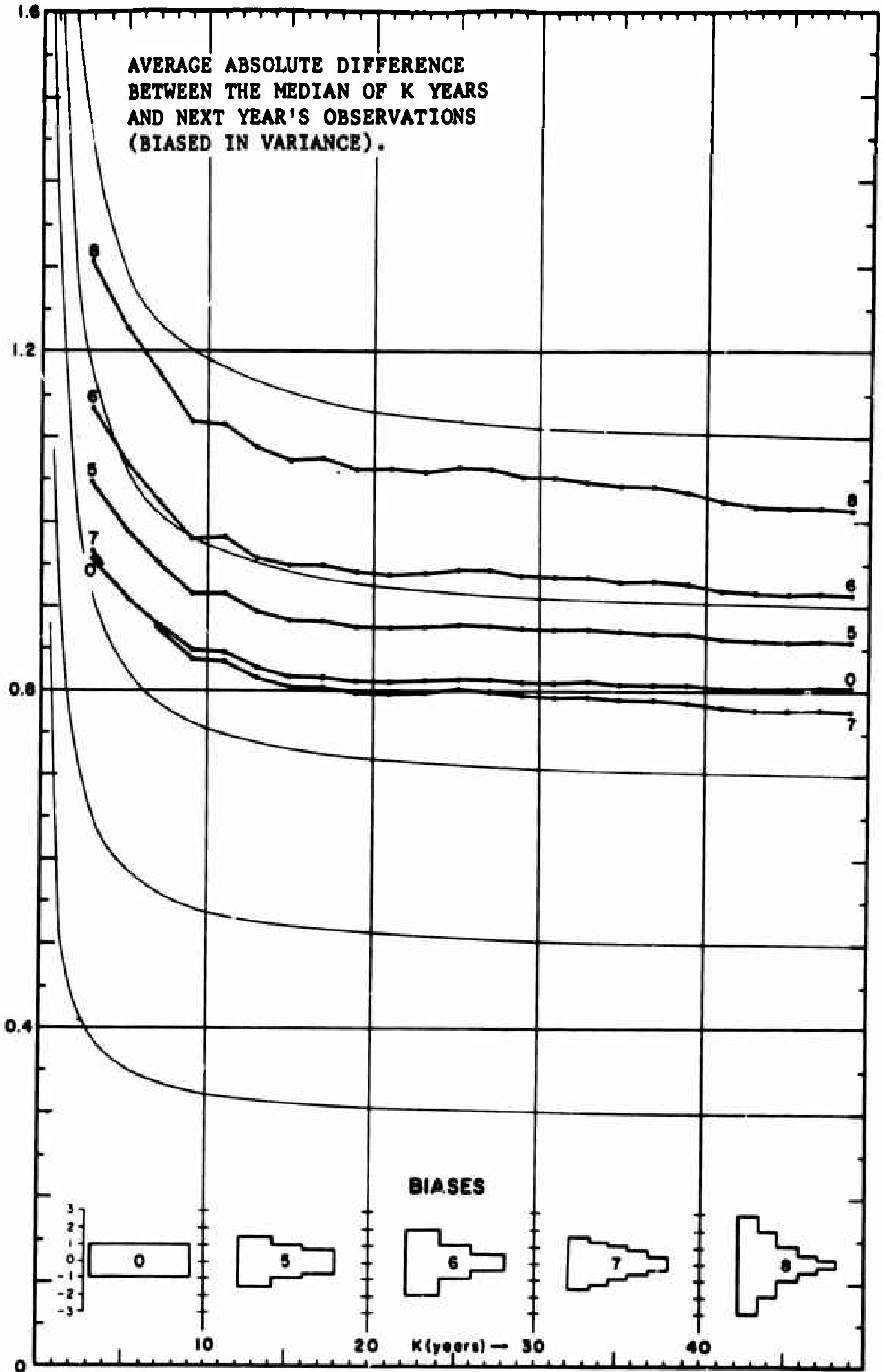
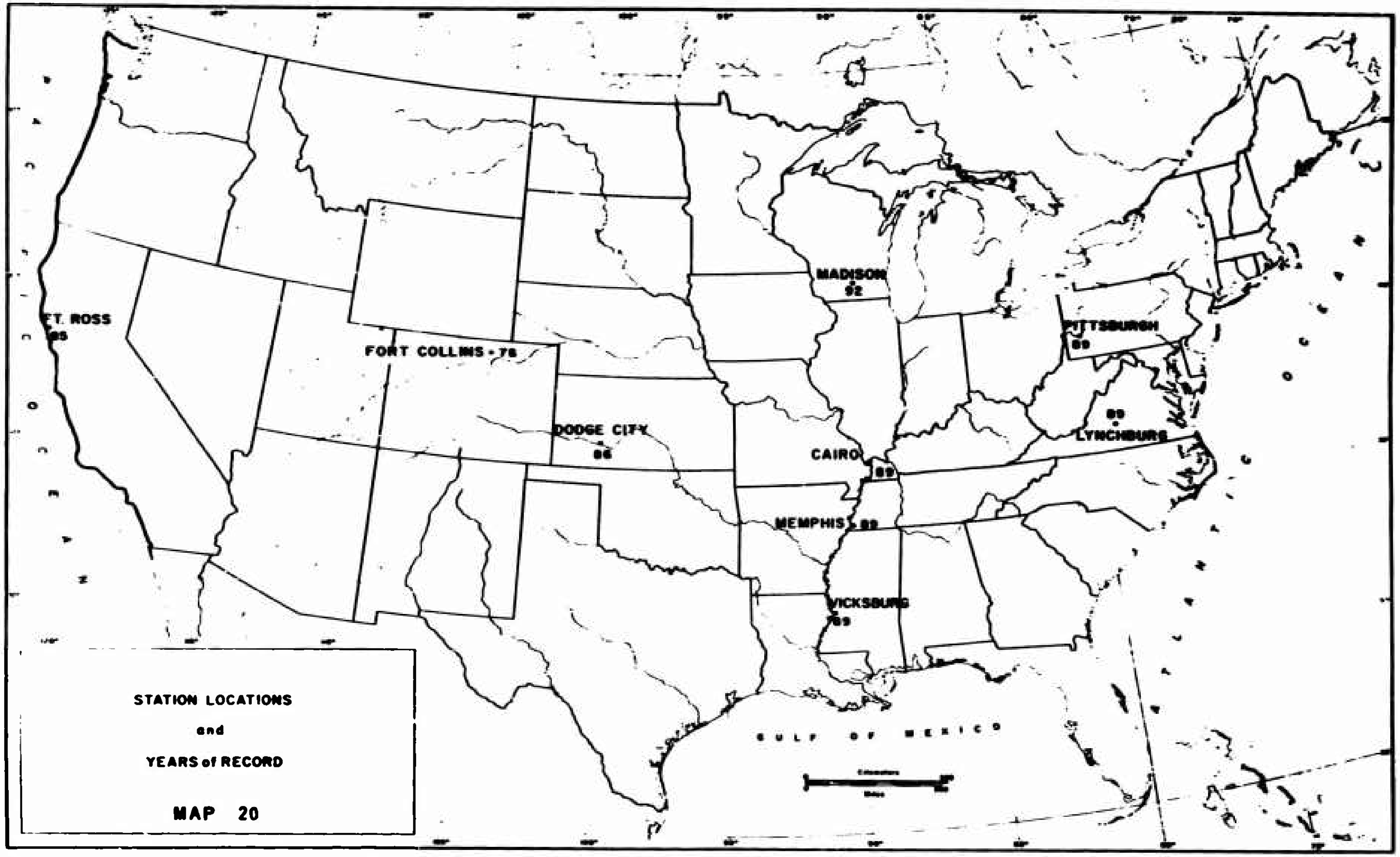

AVERAGE ABSOLUTE DIFFERENCE BETWEEN THE MEDIAN OF K YEARS AND NEXT YEAR'S OBSERVATION (BIASED IN MEAN).
1.6
1.2
0.8
0.4
0
2.0
1.0
-1.0
-2.0
n=1000
01
.10
.30
.70
.90
.99
BIASES
0
1
2
3
4
10
20
K(years)
30
40

FIGURE 9.



AVERAGE ABSOLUTE DIFFERENCE
BETWEEN THE MEDIAN OF K YEARS
AND NEXT YEAR'S OBSERVATIONS
(BIASED IN VARIANCE).
1.6
1.2
0.8
0.4
0
8
6
5
7
0
BIASES
3
2
1
0
-1
-2
-3
10
20
K(years) — 30
40

FIGURE 10.



STATION LOCATIONS
and
YEARS of RECORD

MAP 20

A second table was then prepared (see Table 4). Here the values for Q_k and D_k at k* are given, instead of the value of k* itself. As mentioned before, D_k is not comparable with S_k^2 and therefore S_k^2 is not included; however, since the object of this study is to determine the relative merits of the mean and median, the comparison of only Q_k and D_k will be sufficient.

Table 4 clearly shows that the median is a better value than the mean for estimating future values. In nearly two-thirds of the cases studied the value of D_k is lower than that for Q_k.

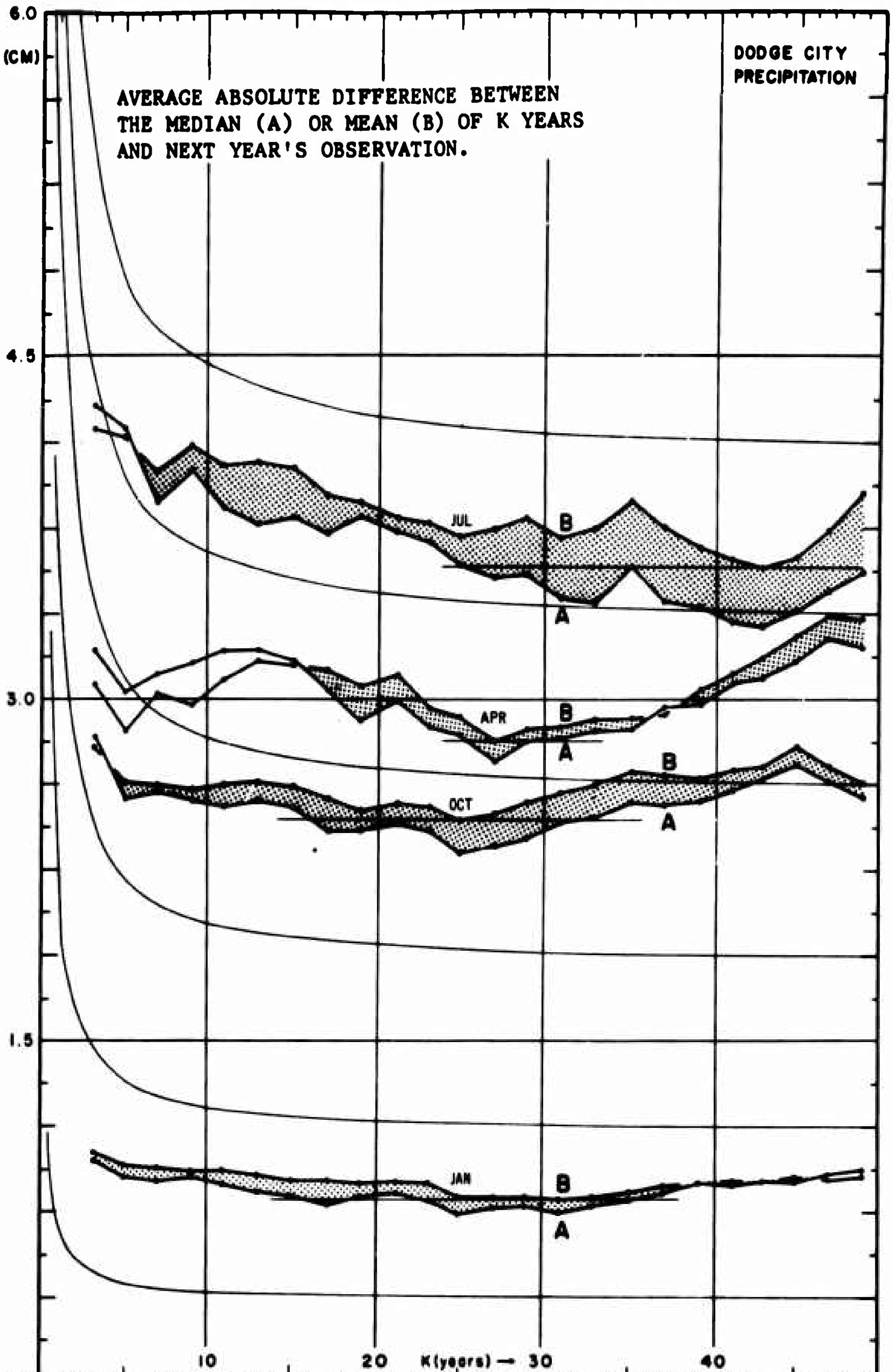
To further bring out the advantages of the median over the mean Figures 11-13 were prepared showing the values of Q_k and D_k for the odd values of k from 3 to 49. It can be seen that a fewer number of years is required to obtain D_k than is required to obtain Q_k of the same value.

When m is varied from one to ten to predict beyond next year, it is found that k* decreases as m becomes larger. This phenomenon occurs regardless of what statistic is being used. This "extension" is clearly seen in Figure 14. The reason for this extension is not clear at present, but is being studied by Dr. Court and will be included in a future report.

TABLE 4.--OPTIMUM VALUES OF Q_k AND D_k[1]

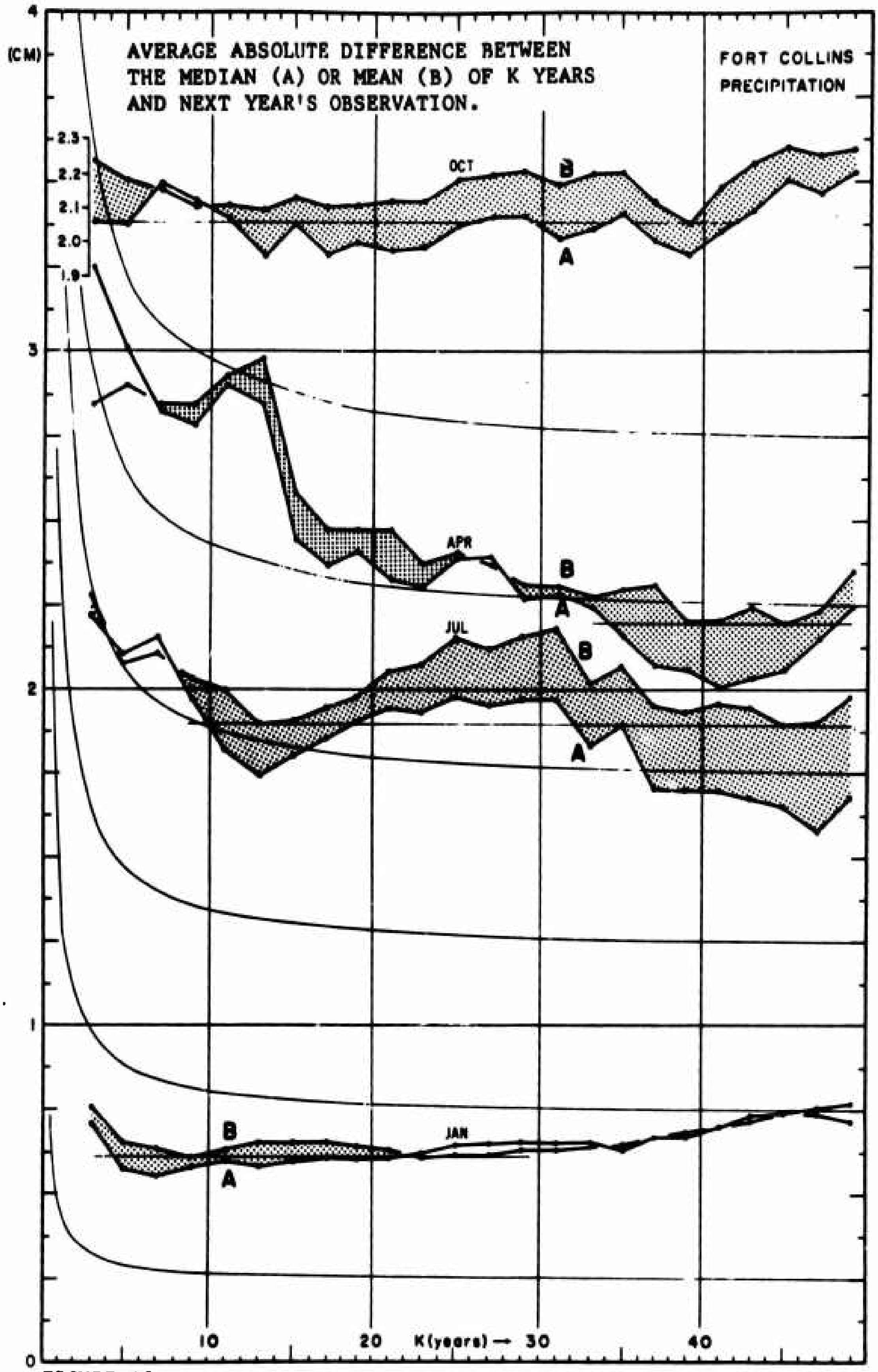
STATION	JAN Q_k	JAN D_k	FEB Q_k	FEB D_k	MAR Q_k	MAR D_k	APR Q_k	APR D_k	MAY Q_k	MAY D_k	JUN Q_k	JUN D_k
Ft. Ross	9.96	8.21	8.67	7.89	6.49	5.84	4.88	4.89	2.94	2.62	1.78	1.47
Ft. Collins	.61	.55	.64	.61	1.15	1.15	2.18	2.01	2.79	2.74	2.12	2.17
Dodge City	.80	.74	1.08	1.07	1.71	1.65	2.82	2.73	3.77	3.78	3.70	3.57
Vicksburg	5.56	5.29	5.09	5.09	4.38	4.38	5.78	5.54	4.48	4.50	4.51	4.32
Memphis	6.70	6.43	4.64	4.46	4.99	4.97	5.45	5.52	4.44	4.65	4.15	4.15
Cairo	5.64	5.51	3.70	3.66	5.23	5.18	3.43	3.56	4.53	4.53	5.13	4.91
Madison	1.87	1.86	1.60	1.59	1.71	1.72	2.40	2.39	3.55	3.44	3.33	3.33
Pittsburgh	2.72	2.67	2.12	2.05	2.81	2.83	2.59	2.64	3.01	3.09	3.33	3.39
Lynchburg	2.90	2.89	2.36	2.29	3.37	3.36	2.30	2.30	3.56	3.58	3.89	3.91

STATION	JUL Q_k	JUL D_k	AUG Q_k	AUG D_k	SEP Q_k	SEP D_k	OCT Q_k	OCT D_k	NOV Q_k	NOV D_k	DEC Q_k	DEC D_k	YR Q_k	YR D_k
Ft. Ross	.16	.13	.27	.18	1.58	1.12	3.88	3.41	7.71	6.83	9.71	9.19		
Ft. Collins	1.89	1.58	2.35	2.18	2.59	2.23	2.05	1.96	.78	.81	.91	.84		
Dodge City	3.57	3.32	2.75	2.68	2.37	2.34	2.47	2.32	1.59	1.60	.91	.92	11.88	11.81
Vicksburg	5.23	5.29	3.96	3.99	4.37	3.84	4.02	3.41	5.34	4.86	4.55	4.22	18.11	18.13
Memphis	3.85	3.90	3.52	3.25	4.10	3.91	4.38	4.29	4.42	4.27	4.81	4.58	22.84	21.21
Cairo	3.78	3.93	4.32	4.32	4.02	4.12	3.68	3.66	4.65	4.72	3.34	3.36	17.39	17.44
Madison	3.61	3.55	3.62	3.59	4.50	4.39	2.72	2.72	2.48	2.51	1.22	1.26	9.68	9.76
Pittsburgh	3.33	3.16	3.36	3.32	3.06	2.97	3.25	3.31	2.53	2.48	2.19	2.27	10.30	10.30
Lynchburg	3.85	3.77	5.21	5.01	4.75	4.33	3.93	3.73	3.15	3.06	2.53	2.48	15.12	15.07



6.0
(CM)
DODGE CITY
PRECIPITATION
AVERAGE ABSOLUTE DIFFERENCE BETWEEN
THE MEDIAN (A) OR MEAN (B) OF K YEARS
AND NEXT YEAR'S OBSERVATION.
4.5
JUL
B
A
3.0
APR
B
A
B
OCT
A
1.5
JAN
B
A
0
10
20
K(years) → 30
40

FIGURE 11.



AVERAGE ABSOLUTE DIFFERENCE BETWEEN
THE MEDIAN (A) OR MEAN (B) OF K YEARS
AND NEXT YEAR'S OBSERVATION.
FORT COLLINS
PRECIPITATION
(CM)
4
3
2
1
0
2.3
2.2
2.1
2.0
1.9
OCT
APR
JUL
JAN
A
B
10
20
K(years) →
30
40

FIGURE 12.

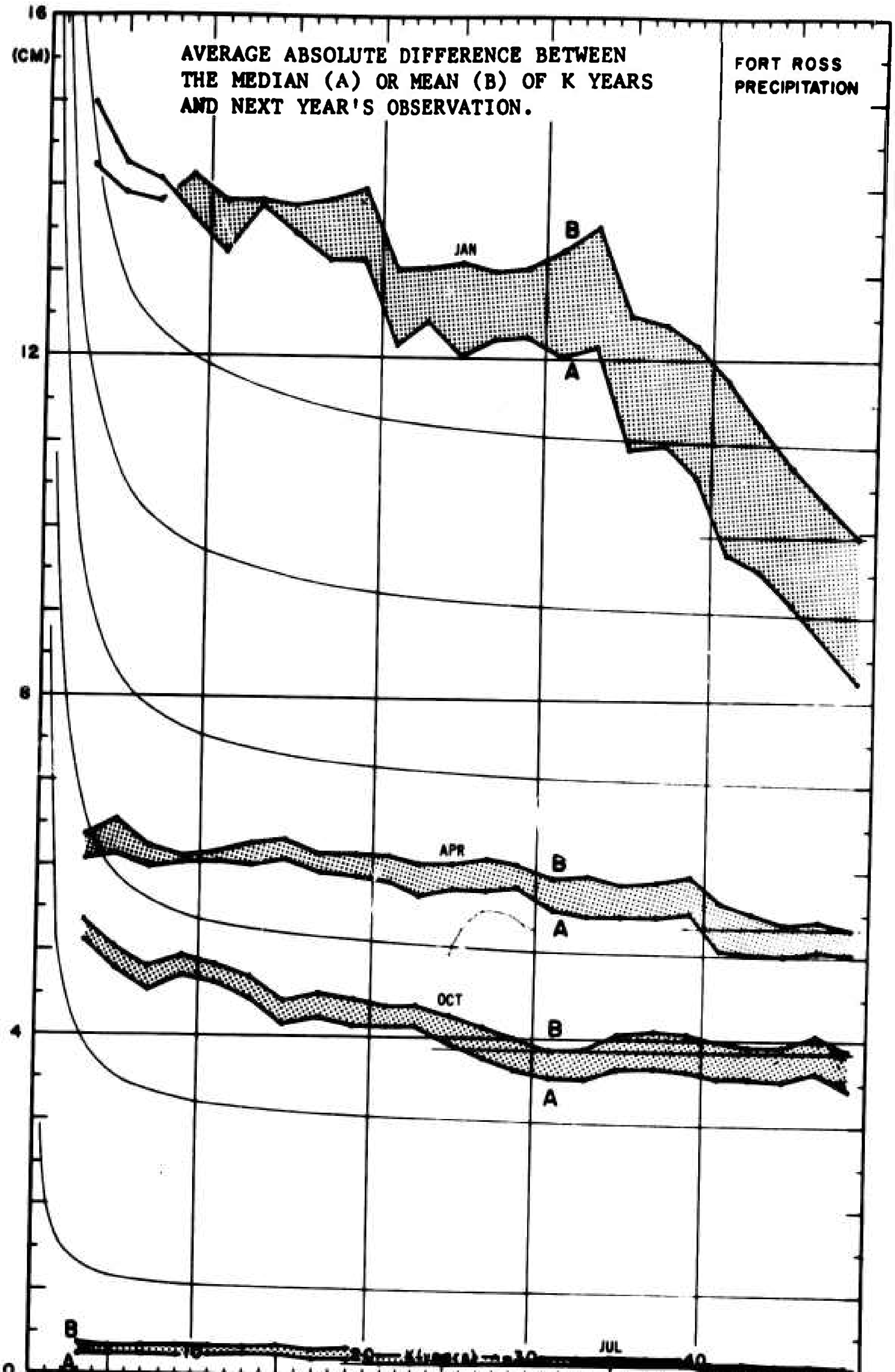

16
(CM)
12
8
4
0
AVERAGE ABSOLUTE DIFFERENCE BETWEEN
THE MEDIAN (A) OR MEAN (B) OF K YEARS
AND NEXT YEAR'S OBSERVATION.
FORT ROSS
PRECIPITATION
JAN
APR
OCT
JUL
B
A
10
20
30
40

FIGURE 13.

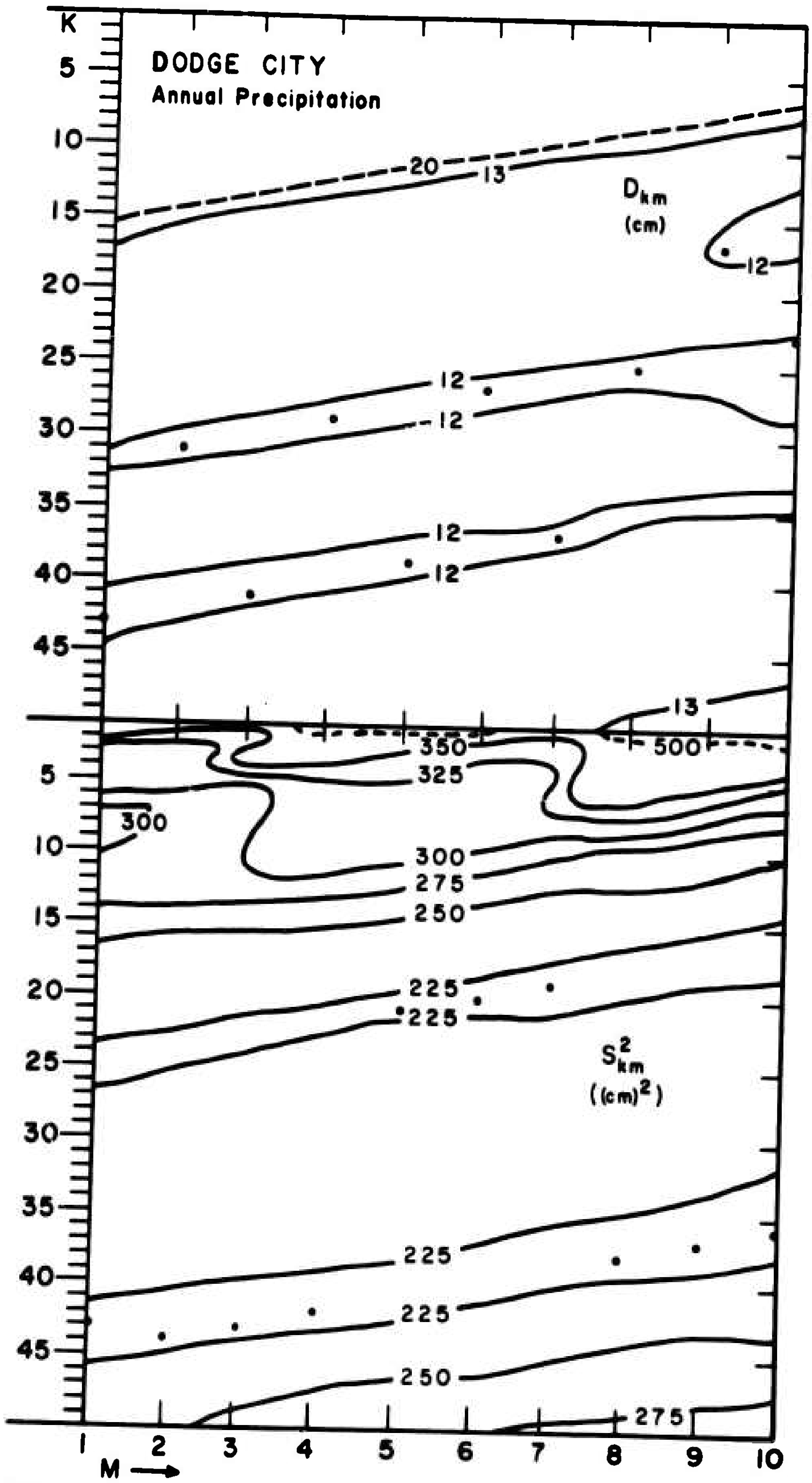


FIGURE 14.--EXTENSION

CHAPTER V

CONCLUSIONS

In climatology, as in many other areas of geography, it is often necessary to characterize entire sets of observations by a single value. In the past the arithmetic average, or mean, has been the most generally used value. Many variables have values that have the opportunity for downward variation strictly limited by zero, while upward variations are theoretically unlimited. Yet it is the lower values that dominate the geography of an area. Here the use of the mean is particularly at fault.

The arithmetic mean has been shown by the many maps contained in this thesis to be a questionable, or at least misleading, descriptive value. The arithmetic mean has been hitherto employed as a measure of central tendency for convenience of description. The indubitable advantages of the arithmetic mean are the ease with which it is calculated (at least before the advent of the computer), and the fact that the sum of the twelve monthly normals is equal to the average of annual totals. Its chief fault lies in the fact that equivalence of weight is given to each unit by which an individual record departs from the mean.

Climates are not constant in position and it is fallacious to regard them as being so. The search for any valid mean expression would seem foredoomed to failure. Climatic statistics must therefore be examined in their entirety, and obsolete normals must be replaced by indices of probability, as exemplified in the Atmospheric Humidity Atlas--Northern Hemisphere (Gringorten et al, 1966). The first step toward this goal would be to replace the arithmetic mean with the median.

Many studies are liable to the biased errors inherent in the arithmetic mean and the temptation to beg the whole question when phenomena are submitted to subjective examination. Neither of these dangers would seem to offer much difficulty when squarely faced; but the more elaborate and refined the subsequent analysis, the easier it is to overlook initial limitations.

The present notion that the mean value is something that will recur, or that it is the value which best represents what we expect to happen again, should be replaced. The knowledge that the mean is only one measure of central tendency, and a poor one at that when considering many of the climatological variables, supports such replacement. In the future it is hoped that summaries of climatological data will feature the median along with, or instead of, the mean.

Climatology is not the only subfield of geography where skewed distributions are encountered. Many geographical distributions are singly or doubly bounded and since geographers are interested in reducing large amounts of data to representative values which can then be used to describe an area or compared with other values, it is of the utmost importance that the values are comparable and best estimate the actual distribution. While the mean may have some computational advantages, it still fails to represent the most typical value in many distributions. This failure has been recognized for a few extremely skewed distributions, and the median values are now in general use to represent 'average' income and 'average' number of years of education. But the arithmetic mean continues to be used to portray values of agricultural, industrial, and mineral production; to indicate consumption of goods; to summarize climatic conditions; and many other variables which might be better portrayed by the median.

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APPENDIX I

TABLE 1.--PRECIPITATION STATIONS FOR WHICH MONTHLY VALUES WERE USED

(Discussed on Pages 10-13)

SEQUENCE NUMBER	STATION I.D. NO.	STATION NAME	LATITUDE NORTH	LONGITUDE WEST	YEARS OF RECORD (ENDING 1960)
1	2.185	Clifton	33.05	109.28	52
2	2.359	Grand Canyon National Park	36.05	112.12	40
3	2.574	Mount Trumball	36.42	113.33	30
4	2.632	Payson RS	34.23	111.33	34
5	2.656	Pinal Ranch	33.35	110.98	65
6	2.680	Prescott	34.55	112.45	52
7	2.882	Tucson University of Arizona	32.23	110.95	66
8	2.965	Yuma Citrus Station	32.62	114.65	40
9	3.023	Arkansas City	33.62	91.20	72
10	3.046	Batesville Land D. No. 1	35.75	91.63	61
11	3.160	Conway	35.08	92.47	77
12	3.244	Fayettesville Exp. Station	36.10	94.17	70
13	3.476	Mena	34.58	94.25	50
14	3.504	Mountain Home 1 NNW	36.33	92.38	44
15	3.582	Pochontas	36.27	90.98	67
16	3.693	Subiaco	35.30	93.65	63
17	4.023	Antioch F. Mills	38.02	121.77	81
18	4.038	Auburn	38.90	121.07	61
19	4.076	Big Creek Power House	37.20	119.25	45
20	4.079	Big Sur State Park	36.25	121.78	46
21	4.170	Chester	40.30	121.22	50
22	4.316	Fort Bragg	39.95	123.80	61
23	4.319	Fort Ross	38.52	123.25	85
24	4.402	Hollister	36.85	121.40	87
25	4.522	Lytle Creek Power House	34.20	117.45	55
26	4.545	McCloud	41.27	122.13	50
27	4.612	Needles	34.77	114.62	69
28	4.618	Newport Beach Harbor	33.60	117.88	30
29	4.640	Ojai	34.45	119.25	56
30	4.774	San Diego WB APT.	32.73	117.17	111

31	4.785	San Luis Obispo Poly	35.30	120.67	91
32	4.804	Scotia	40.48	124.10	35
33	4.835	Sonora	37.98	120.38	73
34	4.897	Topanga Patrol Station FC 6	34.08	118.60	30
35	4.904	Trona	35.78	117.38	41
36	4.909	Tustin Irvine Ranch	33.73	117.78	84
37	4.911	Twin Lakes	38.70	120.05	38
38	4.945	Wasco	35.60	119.33	61
39	4.949	Weaverville Rs.	40.73	122.93	71
40	4.970	Willows	39.53	122.20	82
41	5.129	Cannon City	38.43	105.27	67
42	5.153	Cheesman	39.22	105.28	58
43	5.156	Cheyenne Wells	38.82	102.35	64
44	5.218	Del Norte	37.67	106.35	34
45	5.243	Durango	37.28	107.88	66
46	5.300	Fort Collins	40.58	105.08	63
47	5.304	Fort Morgan	40.25	103.80	54
48	5.441	Julesburg	41.00	102.25	49
49	5.483	Las Animas	38.07	103.22	94
50	5.572	Montrose No. 2	38.48	107.88	70
51	5.762	Shoshone	39.57	107.23	51
52	5.794	Steamboat Springs	40.50	106.83	51
53	5.929	Yuma	40.12	102.73	71
54	10.001	Aberdeen Expt. Station	42.95	112.83	46
55	10.045	Arrowrock Dam	43.60	115.92	49
56	10.141	Cambridge	44.57	116.68	58
57	10.271	Dubois Expt. Station	44.25	112.20	39
58	10.394	Hailey RS	43.52	114.32	52
59	10.501	Kooskia	46.15	115.98	52
60	10.654	Oakley	42.23	113.88	67
61	10.808	Salmon	45.18	113.88	38
62	10.814	Sandpoint Expt. Station	48.28	116.57	50
63	13.036	Atlantic 1 NE	41.42	95.00	70
64	13.221	Des Moines WB City	41.58	93.62	83
65	13.523	Mason City 3N	43.16	93.20	58
66	13.639	Ottuma	41.00	92.43	68
67	13.716	Rockwell City	42.40	94.62	65
68	14.177	Concordia WB City	39.57	97.67	75
69	14.187	Council Grove	38.67	96.50	52
70	14.246	Ellsworth	38.73	98.23	56

71	14.376	Holton	39.47	95.73	48
72	14.442	La Cygne	38.35	94.77	30
73	14.517	Medicine Lodge	37.27	98.58	68
74	14.637	Phillipsburg	39.77	99.32	69
75	14.643	Plains	37.27	100.58	51
76	14.664	Quinter	39.07	100.23	30
77	14.731	Sedan	37.12	96.17	76
78	14.731	Sedgwick	37.92	97.43	44
79	14.819	Toronto	37.80	95.95	64
80	16.141	Calhoun Expt. Station	32.52	92.33	69
81	16.470	Jennings	30.23	92.67	63
82	16.612	Melville	30.68	91.75	74
83	16.666	New Orleans WB City	29.95	90.07	91
84	16.734	Plain Dealing	32.90	93.68	67
85	16.892	Tallulah Delta Lab.	32.40	91.22	43
86	23.130	Capringer Mills	37.80	93.80	34
87	23.158	Chillicothe 25	39.75	93.55	43
88	23.223	Dexter	36.80	89.97	37
89	23.250	Eldon	38.35	92.58	57
90	23.282	Fayette	39.15	92.68	76
91	23.304	Fredericktown	37.57	90.30	36
92	23.379	Hermann	38.70	91.45	86
93	23.598	Neosho	36.87	94.37	78
94	23.772	Shelbina	39.68	92.05	[illegible]
95	23.871	Warrensburg	38.77	93.73	77
96	23.899	Willow Springs	36.98	91.97	37
97	24.036	Augusta	47.48	112.38	34
98	24.043	Ballantine	45.95	108.13	41
99	24.077	Big Sandy	48.17	110.12	37
100	24.104	Bozeman Agri, College	45.67	111.05	58
101	24.260	East Anaconda	46.10	112.92	55
102	24.269	Ekalaka	45.97	104.53	56
103	24.314	Fortine Inne	48.78	114.90	39
104	24.389	Hamilton	46.25	114.15	33
105	24.398	Haugan	47.38	115.40	48
106	24.452	Jordan	47.32	106.90	30
107	24.529	Lustre 4 NNW	48.45	105.93	39
108	24.576	Moccasin Expt. Station	47.05	109.95	30
109	24.729	Saint Ignatius	47.32	114.10	52
110	24.881	West Glacier	48.50	113.98	35

111	25.093	Blair	41.55	96.13	91
112	25.115	Bridge Port	41.67	103.10	63
113	25.202	Crete	40.62	96.95	81
114	25.280	Ewing	42.25	98.35	68
115	25.302	Fort Robinson	42.67	103.47	77
116	25.318	Genoa	41.45	97.73	85
117	25.363	Hartington	42.62	97.27	69
118	25.697	Purdum	42.07	100.25	58
119	25.704	Ravenna	41.03	98.92	83
120	26.005	Adaven	38.12	115.58	42
121	26.257	Elko WB Apt.	40.83	115.78	91
122	26.517	Ming	38.38	118.10	53
123	26.678	Reno WB Apt.	39.50	119.78	90
124	29.152	Carrizozo	33.65	105.88	52
125	29.181	Cimarron	36.52	104.92	57
126	29.194	Clovis	34.40	103.20	49
127	29.285	Elida	33.95	103.65	45
128	29.327	Fort Bayard	32.80	108.15	90
129	29.378	Hachita	31.92	108.32	51
130	29.474	Lake Avalon	32.48	104.25	46
131	29.668	Pecos RS	35.58	105.68	37
132	29.854	State University	32.28	106.75	100
133	29.990	Zuni FAA AP.	35.10	108.78	46
134	32.219	Dickenson Expt. Station	46.88	102.80	69
135	32.362	Grand Forks U.	47.92	97.08	69
136	32.442	Jamestown St. Hosp.	46.88	98.68	68
137	32.564	Max	47.82	101.30	30
138	32.602	Mohall	48.77	101.52	67
139	34.350	Geary	35.63	98.32	49
140	34.445	Idabel	33.90	94.82	34
141	34.477	Kenton	36.92	102.97	60
142	34.693	Pauls Valley	34.75	97.22	57
143	34.701	Perry	36.28	97.28	30
144	34.945	Webber Falls	35.52	95.13	62
145	34.963	Wichita Mt. Wlr	34.73	98.72	45
146	35.020	Antelope 1N	44.92	120.72	36
147	35.069	Bend	44.07	121.32	50
148	35.190	Cottage Grove 1 S	43.78	123.07	44
149	35.214	Danner	42.93	117.33	30
150	35.269	Estachada 2 SE	45.27	122.32	52

151	35.344	Grants Pass	42.43	123.32	72
152	35.383	Heppner	45.33	119.55	55
153	35.467	Lakeview	42.18	120.35	48
154	35.561	Minam 7 NE	45.68	117.60	51
155	35.691	Prospect 2 SW	42.73	122.52	53
156	35.725	Rock Creek	44.75	118.08	41
157	35.905	Warm Springs Reservoir	43.57	118.20	30
158	39.030	Armour	43.32	98.35	63
159	39.197	Cotton Wood	43.97	101.87	51
160	39.280	Eureka	45.77	99.62	52
161	39.383	Highmore 1 W	44.52	99.47	58
162	39.401	Hot Springs	43.43	103.47	57
163	39.466	Ladelle 7 NE	44.68	98.00	64
164	39.486	Lemmon	45.93	102.17	44
165	39.554	Milbank	45.22	96.63	71
166	39.767	Sioux Fall WB AP	43.57	96.73	70
167	39.855	Vale	44.62	103.40	52
168	39.944	Wood	43.50	100.48	48
169	41.012	Albany	32.73	99.30	79
170	41.050	Balmorhea Exp. Station	31.00	103.68	37
171	41.061	Beaumont	30.08	94.10	68
172	41.114	Brownwood	31.72	98.98	68
173	41.202	Corsicana	32.08	96.47	75
174	41.318	Flatonia	29.68	97.10	53
175	41.343	Galveston WB City	29.30	94.83	89
176	41.351	George West	28.35	98.12	45
177	41.373	Greenville 2 SW	33.12	96.13	59
178	41.408	Henderson	32.15	94.80	52
179	41.478	Kerrville	30.03	99.13	65
180	41.502	Lampasas	31.05	98.18	66
181	41.597	Mission	26.22	98.32	40
182	41.695	Perryton	36.40	100.82	48
183	41.721	Post	33.20	101.37	44
184	41.726	Presidio	29.55	104.40	30
185	41.765	Riverside	30.85	95.40	57
186	41.863	Sterling City	31.85	100.98	30
187	41.928	Valley Junction	30.83	96.63	58
188	41.933	Vega	35.25	102.43	30
189	41.953	Weatherford	32.75	97.80	67
190	42.210	Deseret	39.28	112.65	61

191	42.300	Fort Duchesne	40.28	109.85	71
192	42.390	Hiawatha	39.48	111.02	39
193	42.451	Kanab Power House	39.05	112.52	39
194	42.515	Loa	38.40	111.65	57
195	42.565	Milford WB Apt.	38.43	113.02	44
196	42.727	Richmond	41.90	111.82	49
197	42.812	Spanish Fork Power House	40.08	111.60	50
198	42.877	Tooele	40.53	112.30	64
199	45.092	Brooklyn	46.77	123.52	30
200	45.122	Cedar Lake	47.42	121.95	58
201	45.135	Chelan	47.83	120.03	69
202	45.159	Colfax 1 NW	46.88	117.38	69
203	45.322	Goldendale	45.82	120.83	50
204	45.355	Hatton 8 E	46.77	118.67	56
205	45.477	Longview	46.17	122.92	36
206	45.584	Newhalem	48.68	121.25	36
207	45.704	Rimrock Teton Dam	46.65	121.13	51
208	45.751	Sedro Wolley 1 E	48.50	122.22	64
209	45.758	Shelton	47.20	123.10	30
210	45.821	Sunnyside	46.32	120.00	66
					77
211	45.833	Tatoosh Island WB	48.38	124.73	77
212	45.938	Winthrop 1 WSW	48.47	120.18	39
213	48.118	Buffalo Bill Dam	44.50	109.18	48
214	48.272	Dubois	43.55	109.62	48
215	48.407	Green River	41.53	109.48	40
216	48.583	Lusk	42.77	104.43	62
217	48.710	Pathfinder Dam	42.47	106.83	60
218	48.816	Sheridan Field Station	44.85	106.87	43
219	48.991	Yellowstone Park	44.97	110.70	72

CLIMATIC PREDICTION

Optimum Length of Record

1. Origin of Program

This program was prepared in the Climatology Laboratory of San Fernando Valley State College, Northridge, California by Paul E. Roy, Jr. and William F. Slusser as part of Air Force Project "Optimum Record for Climatic Estimation and Prediction," to assist in the analysis of climatic data to determine the optimum length of record for climatic prediction.

2. Purpose of Program

This program accepts monthly and yearly data in varied formats (Sec. 5) and computes the extrapolation variance, S(k,m), the absolute prediction error using the mean, Q(k,m), and the median, D(k,m) for varying k year periods and observations m years ahead. It then finds the optimum length of record (k*) for each of these and computes F(k,m), QF(k,m), and DF(k,m), the percentage difference between the value obtained at k* and that found using the other values of k.

3. Description of Equipment

This program was developed for use on the IBM 360/75, but can be used on most computers using Fortran IV.

4. Method of Computation

a. S(k,m) is obtained by averaging the squared differences between the mean of k successive observations and an observation m years later for which the value is to be estimated from that for the k years.

Q(k,m) and D(k,m) are obtained by averaging the absolute differences of the same periods.

Values of k from 1 to any desired length of record may be used to obtain values for S(k,m) and Q(k,m) while only odd values of k beginning with 3 are used for finding values of D(k,m).

Lastly, m varies from 1 to 10.

b. F(k,m), QF(k,m), and DF(k,m) are obtained by dividing all values of S(k,m), QF(k,m), and D(E,m) respectively by the minimum value obtained for each and multiplying by 100. These minimum or optimum values are indicated on the print out by an asterisk (*), and the value of k at which the value is obtained is known as the optimum length of record (k*).

Sums for F(k,1), QF(k,1), and DF(k,1) of the twelve monthly values for each value of k are given on the last page of output.

c. The program also supplies a print out of all data used in the calculations serving as a check to see that the data is properly read.

5. Input

The format of the data to be examined is read in so that the program is readily useable (see Input description). The program uses monthly and annual data in chronological order. Since a doubly dimensioned array is used, each card should contain all or any number of months of one year only, along with the annual value if desired. The order of the months on the data card must coincide with the order of the months on card B (see Input description).

6. Output

All output is in printed form, as summarized by the illustration.

7. Operating Instructions

Standard Fortran IV is used. No sense switches are used. At the present the program does not handle tapes, but it can be easily modified to do so.

8. Description of Terms

IN	- physical input unit
IOUT	- physical output unit
NST	- the symbol for denoting the minimum value
NBL	- the symbol denoting other than minimum value
XMON(I)	- thirteen three letter words: Jan, Feb, . . .Sum; or Yr
KMAX	- the maximum value of k
N	- the number of observations per month (or year)
ISETS	- the number of sets of data per card
NNAME(I)	- the name of the station, the variable, and the years of record
FMT(I)	- the format of the data being read in
X(L,NH)	- value of observation, monthly or annual
SDF(K)	- sum of monthly values of DF(k,m)
SAF(K)	- sum of monthly values of QF(k,m)
SF(K)	- sum of monthly values of F(k,m)
XMIN(M)	- minimum value of Q(k,m)
XMIN(M)	- minimum va lue of S(k,m), SQ or D(k,m)
Y(J)	- the mean or median value of a k year period
SSUM1	- sum of absolute differences using mean
SSUM	- sum of absolute differences using median or squared differences using mean
S(K,M)	- extrapolation variance or absolute prediction error using mean

Q(K,M) - the absolute prediction error using the mean

LOC(M) - the value of k where NST is to be placed

NBLANK(K,M) - the symbol to be printed after each value of S(k,m), SQ or D(k,m)

MBLANK(K,M) - the symbol to be printed after each value of Q(k,m)

Z(MID) - the median of k years

INPUT DESCRIPTION

A. One card containing an asterisk (*) in the first column.

B. One card containing the names of the months using columns 1 through 36, three columns per month. If annual data is included, sum or yr should be punched in columns 37 through 39.

C. One card containing the maximum value of k desired in columns 1 through 3; the number of years of record in columns 4 through 6; the number of sets of observations (13 if all months and the annual amount are included) in columns 7 through 8; and the station name, variable name, and date of beginning and end of observations in the remainder of the columns.

D. One card containing the format of the data in the first 60 columns.

E. Data

F. Each successive group of data requires only cards C and D.

```
      DIMENSION X(13,206),Y(206),SF(50),S(50,11),T(50),NBLANK(50,11),
     1XMIN(11),LOC(11),XMON(13),NTBL(50),NNAME(24),SUM(100)
      DIMENSION Z(100),SAF(50),Q(50,11),MBLANK(50,11),LOC1(11)
      DIMENSION FMT(20),XMIN1(11),SDF(50)
    1 FORMAT (////14H F(K,M)    FOR ,A3,5H OF A,I4,13H YEAR PERIOD ,24A3
     1,///3H M=,6X,1H1,8X,1H2,8X,1H3,8X,1H4,8X,1H5,8X,1H6,8X,1H7,8X,1H8,
     28X,1H9,7X,2H10,                            /3H  K,/)
    2 FORMAT (////14H F(K,M)    FOR ,A3,5H OF A,I4,13H YEAR PERIOD ,24A3
     1,///7X,4HMEAN,2X,13HABSOLUTE MEAN,1X,6HMEDIAN,/3H  K,/)
    3 FORMAT (////////10H DATA FOR ,A3,5H OF A, I4,13H YEAR PERIOD ,
     124A3,//,21(1H ,10F10.1,//))
    4 FORMAT (////14H S(K,M)SQ FOR ,A3,5H OF A,I4,13H YEAR PERIOD ,24A3
     1,///3H M=,6X,1H1,8X,1H2,8X,1H3,8X,1H4,8X,1H5,8X,1H6,8X,1H7,8X,1H8,
     28X,1H9,7X,2H10,                            /3H  K,/)
    5 FORMAT (1H ,I3,1X,12(F8.2,A1))
    6 FORMAT (1H ,I3,1X,3F8.3)
    7 FORMAT (13A3)
    8 FORMAT (2A1)
    9 FORMAT (1H1)
   10 FORMAT (////15H QF(K,M)    FOR ,A3,5H OF A,I4,13H YEAR PERIOD ,24A3
     1,///3H M=,6X,1H1,8X,1H2,8X,1H3,8X,1H4,8X,1H5,8X,1H6,8X,1H7,8X,1H8,
     28X,1H9,7X,2H10,                            /3H  K,/)
   11 FORMAT (////15H  Q(K,M)    FOR ,A3,5H OF A,I4,13H YEAR PERIOD ,24A3
     1,///3H M=,6X,1H1,8X,1H2,8X,1H3,8X,1H4,8X,1H5,8X,1H6,8X,1H7,8X,1H8,
     28X,1H9,7X,2H10,                            /3H  K,/)
   12 FORMAT (////15H DF(K,M)    FOR ,A3,5H OF A,I4,13H YEAR PERIOD ,24A3
     1,///3H M=,6X,1H1,8X,1H2,8X,1H3,8X,1H4,8X,1H5,8X,1H6,8X,1H7,8X,1H8,
     28X,1H9,7X,2H10,                            /3H  K,/)
   14 FORMAT (////14H D(K,M)    FOR ,A3,5H OF A,I4,13H YEAR PERIOD ,24A3
     1,///3H M=,6X,1H1,8X,1H2,8X,1H3,8X,1H4,8X,1H5,8X,1H6,8X,1H7,8X,1H8,
     28X,1H9,7X,2H10,                            /3H  K,/)
   15 FORMAT (2I3,I2,24A3)
   16 FORMAT (20A3)
      IN=5
      IOUT=6
      READ(IN,8)NST,NBL
      READ(IN,7)(XMON(I),I=1,13)
      DO 53 IXK=1,7
C     READ IN DATA
      READ(IN,15)KMAX,N,ISETS,NNAME
      READ(IN,16)FMT
      DO 17 NH=1,N
      READ(IN,FMT)(X(L,NH),L=1,ISETS)
   17 CONTINUE
      DO 18 K=1,KMAX
      SDF(K)=0.0
      SAF(K)=0.0
   18 SF(K)=0.0
C     CALCULATES DEPARTURES FROM MEAN
      DO 51 II=1,ISETS
      LL=II
      XI=II
      DO 19 M=1,11
      XMIN1(M)=9999999.
   19 XMIN(M)=9999999.
      WRITE(IOUT,9)
      WRITE(IOUT,3)XMON(II),N,NNAME,(X(LL,NH),NH=1,N)
      WRITE(IOUT,9)
```

```
      Y(1)=0.0
      DO 27 K=1,KMAX
      L=N-K
      C5=L+1
      C2=1./C5
      C4=K
      C=1./C4
      C1=1./(C4*C4)
      Y(1)=Y(1)+X(LL,K)
      DO 20 MM=1,L
      JJ=MM+1
      NN=MM+K
      Y(JJ)=Y(MM)+(X(LL,NN)-X(LL,MM))
20    CONTINUE
      DO 26 M=1,10
      SSUM1=0.0
      SSUM=0.0
      NMK1=N-M-K+1
      DO 21 J=1,NMK1
      JKM1=J+K+M-1
      SSUM1=SSUM1+(Y(J)*C-X(LL,JKM1))*(Y(J)*C-X(LL,JKM1))
21    SSUM=SSUM+ABS(Y(J)*C-X(LL,JKM1))
      C6=NMK1
      S(K,M)=SSUM1/C6
      Q(K,M)=SSUM/C6
      IF(S(K,M)-XMIN1(M))22,23,23
22    XMIN1(M)=S(K,M)
      LOC1(M)=K
23    MBLANK(K,M)=NBL
      IF(Q(K,M)-XMIN(M))24,25,25
24    XMIN(M)=Q(K,M)
      LOC(M)=K
25    NBLANK(K,M)=NBL
26    CONTINUE
27    CONTINUE
      DO 28 M=1,10
      KK1=LOC1(M)
      KK=LOC(M)
      MBLANK(KK1,M)=NST
28    NBLANK(KK,M)=NST
      WRITE(IOUT,4)XMON(II),N,NNAME
      DO 29 K=1,KMAX
29    WRITE(IOUT,5)K,(S(K,M),MBLANK(K,M),M=1,10)
      WRITE(IOUT,9)
      WRITE(IOUT,11)XMON(II),N,NNAME
      DO 30 K=1,KMAX
30    WRITE(IOUT,5)K,(Q(K,M),NBLANK(K,M),M=1,10)
      WRITE(IOUT,9)
      WRITE(IOUT,1)XMON(II),N,NNAME
      DO 33 K=1,KMAX
      DO 31 M=1,10
      S(K,M)=(S(K,M)/XMIN1(M)-1.)*100.
31    Q(K,M)=(Q(K,M)/XMIN(M)-1.)*100.
      WRITE(IOUT,5)K,(S(K,M),MBLANK(K,M),M=1,10)
      IF (XI-13.)32,33,32
32    SF(K)=SF(K)+S(K,1)
      SAF(K)=SAF(K)+Q(K,1)
33    CONTINUE
```

```
      WRITE(IOUT,9)
      WRITE(IOUT,10)XMON(II),N,NNAME
      DO 34 K=1,KMAX
      WRITE(IOUT,5)K,(Q(K,M),NBLANK(K,M),M=1,10)
   34 CONTINUE
      DO 35 M=1,10
   35 XMIN(M)=9999999.
C     CALCULATES DEPARTURES FROM MEDIAN
      DO 45 K=3,KMAX,2
      L=N-K+1
      J1=1
      J2=K
      MID=(K+1)/2
      DO 40 JJ=1,L
      J5=J2-1
      DO 36 J=J1,J2
   36 Z(J)=X(LL,J)
      DO 39 III=J1,MID
      DO 38 J=J1,J5
      IF(Z(J)-Z(J+1))38,38,37
   37 HOLD=Z(J)
      Z(J)=Z(J+1)
      Z(J+1)=HOLD
   38 CONTINUE
   39 J5=J5-1
      Y(JJ)=Z(MID)
      J1=J1+1
      J2=J2+1
   40 MID=MID+1
      DO 44 M=1,10
      SSUM=0.
      NMK1=N-M-K+1
      DO 41 J=1,NMK1
      JKM1=J+K+M-1
   41 SSUM=SSUM+ABS(Y(J)-X(LL,JKM1))
      C2=NMK1
      S(K,M)=SSUM/C2
      IF(S(K,M)-XMIN(M))42,43,43
   42 XMIN(M)=S(K,M)
      LOC(M)=K
   43 NBLANK(K,M)=NBL
   44 CONTINUE
   45 CONTINUE
      DO 46 M=1,10
      KK=LOC(M)
   46 NBLANK(KK,M)=NST
      WRITE(IOUT,9)
      WRITE(IOUT,14)XMON(II),N,NNAME
      DO 47 K=3,KMAX,2
   47 WRITE(IOUT,5)K,(S(K,M),NBLANK(K,M),M=1,10)
      WRITE(IOUT,9)
      WRITE(IOUT,12)XMON(II),N,NNAME
      DO 50 K=3,KMAX,2
      DO 48 M=1,10
   48 S(K,M)=(S(K,M)/XMIN(M)-1.)*100.
      WRITE(IOUT,5)K,(S(K,M),NBLANK(K,M),M=1,10)
      IF (XI-13.)49,50,49
   49 SDF(K)=SDF(K)+S(K,1)
```

```
50 CONTINUE
51 CONTINUE
   II=13
   WRITE(IOUT,9)
   WRITE(IOUT,2)XMON(II),N,NNAME
   DO 52 K=1,KMAX,2
52 WRITE(IOUT,6)K,SF(K),SAF(K),SOF(K)
53 CONTINUE
   STOP
   END
```

DATA

DATA FOR JAN OF A 100 YEAR PERIOD SANTA BARBARA, CALIF. PRECIPITATION (INCHES) 1868-1967

3.97	3.26	0.25	0.86	2.53	0.58	4.54	14.84	7.56	2.72
7.17	5.24	1.30	2.83	1.13	2.18	6.33	1.23	5.12	0.31
10.15	0.29	5.32	0.45	1.10	4.41	0.99	6.25	6.84	4.35
0.63	4.48	2.32	4.86	1.36	2.06	0.46	3.73	4.26	12.46
4.29	15.67	2.91	14.21	0.42	3.14	15.91	4.94	17.24	3.25
0.51	1.20	0.33	5.32	4.64	1.96	1.63	0.60	2.08	1.94
0.0	1.53	5.82	4.25	2.40	6.42	1.49	4.10	0.73	3.09
1.90	2.84	6.39	9.68	0.80	12.84	1.44	0.60	0.40	0.60
0.0	1.40	2.54	2.53	13.89	1.78	5.98	4.39	7.19	5.39
3.71	2.68	3.12	1.81	2.18	1.79	1.45	0.76	1.51	7.61

S(K,M)SQ FOR JAN OF A 100 YEAR PERIOD SANTA BARBARA, CALIF. PRECIPITATION (INCHES) 1868-1967

M= K	1	2	3	4	5	6	7	8	9	10
1	29.95	21.22	30.80	33.06	30.58	34.35	30.86	32.09	30.19	32.73
2	18.26	18.50	24.42	24.28	24.78	24.92	23.06	23.21	23.59	24.30
3	18.49	19.39	22.55	23.62	22.81	22.36	21.23	22.24	22.08	23.24
4	18.81	18.86	22.14	22.03	20.49	20.67	20.62	21.09	21.40	21.84
5	18.33	19.07	20.96	19.73	19.22	20.11	19.67	20.45	20.47	21.34
6	18.60	18.60	18.97	18.78	19.01	19.39	19.45	19.86	20.31	20.60
7	18.19	16.85	18.13	18.60	18.43	19.16	19.03	19.76	19.77	20.55
8	16.61	16.40	18.10	18.19	18.40	18.87	19.10	19.39	19.89	20.07
9	16.34	16.54	17.88	18.25	18.16	18.94	18.78	19.52	19.63	20.24
10	16.48	16.52	18.00	18.05	18.32	18.67	18.97	19.37	19.82	19.68
11	16.46	16.74	17.85	18.21	18.12	18.86	18.87	19.58	19.34	19.73
12	16.68	16.68	18.01	18.02	18.34	18.81	19.09	19.18	19.39	18.77
13	16.61	16.90	17.84	18.23	18.33	19.01	18.76	19.21	18.51	18.88
14	16.85	16.84	18.08	18.24	18.57	18.72	18.84	18.36	18.65	18.09
15	16.79	17.12	18.09	18.47	18.33	18.80	18.03	18.50	18.76	18.90
16	17.08	17.18	18.34	18.26	18.45	18.00	18.20	18.61	18.71	18.96
17	17.13	17.46	18.14	18.37	17.66	18.15	18.31	18.58	18.78	18.82
18	17.39	17.33	18.24	17.64	17.82	18.28	18.28	18.65	18.67	18.71
19	17.27	17.47	17.51	17.79	17.94	18.26	18.37	18.54	18.58	18.74
20	17.41	16.81	17.67	17.94	17.95	18.36	18.30	18.48	18.64	18.88
21	16.74	17.00	17.81	17.96	18.06	18.30	18.27	18.54	18.76	18.93
22	16.92	17.19	17.82	18.07	18.05	18.27	18.37	18.70	18.85	19.06
23	17.10	17.23	17.95	18.06	18.04	18.36	18.52	18.79	18.99	19.01
24	17.14	17.37	17.95	18.05	18.15	18.51	18.63	18.92	18.96	19.20
25	17.29	17.40	17.96	18.15	18.29	18.62	18.77	18.91	19.15	19.20
26	17.32	17.43	18.06	18.28	18.41	18.78	18.77	19.11	19.17	19.40
27	17.37	17.55	18.20	18.41	18.57	18.79	18.98	19.13	19.37	19.33
28	17.48	17.70	18.34	18.58	18.59	19.00	19.01	19.34	19.31	19.59
29	17.64	17.85	18.50	18.61	18.81	19.05	19.22	19.30	19.56	19.71
30	17.79	18.01	18.54	18.83	18.87	19.25	19.18	19.53	19.69	20.05
31	17.95	18.07	18.76	18.90	19.07	19.21	19.41	19.67	20.03	19.05
32	18.01	18.29	18.83	19.10	19.06	19.45	19.55	20.01	19.00	19.15
33	18.25	18.39	19.04	19.10	19.29	19.60	19.90	18.99	19.11	16.97
34	18.34	18.60	19.04	19.33	19.46	19.95	18.87	19.11	16.92	17.17
35	18.56	18.63	19.28	19.50	19.80	18.94	19.00	16.93	17.13	15.57
36	18.59	18.87	19.45	19.85	18.78	19.07	16.80	17.14	15.50	15.51
37	18.84	19.06	19.60	18.82	18.92	16.96	17.02	15.50	15.45	15.75
38	19.03	19.40	18.74	18.96	16.67	17.07	15.35	15.47	15.69	13.03
39	19.38	18.36	18.89	16.71	16.89	15.40	15.32	15.71	12.98	13.28
40	18.34	18.51	16.66	16.94	15.23	15.37	15.56	13.01	13.23	9.96*
41	18.50	16.37	16.87	15.35	15.18	15.61	12.96	13.27	10.02*	10.29
42	16.37	16.59	15.30	15.30	15.42	13.02	13.23	10.07*	10.36	10.29
43	16.58	15.12	15.22	15.54	12.96	13.30	10.17*	10.39	10.32	10.46
44	15.10	15.05	15.46	13.07	13.24	10.22*	10.49	10.35	10.49	10.33
45	15.00	15.28	13.09	13.35	10.28*	10.54	10.42	10.49	10.32	10.65
46	15.23	12.88	13.37	10.35*	10.59	10.48	10.57	10.34	10.63	10.76
47	12.83	13.16	10.35*	10.66	10.53	10.63	10.42	10.65	10.75	10.87
48	13.11	10.26*	10.65	10.57	10.65	10.44	10.74	10.78	10.83	10.89
49	10.22*	10.56	10.56	10.68	10.47	10.76	10.87	10.86	10.85	10.81
50	10.50	10.42	10.63	10.45	10.79	10.90	10.93	10.85	10.73	10.87

F(K,M) FOR JAN OF A 100 YEAR PERIOD SANTA BARBARA, CALIF. PRECIPITATION (INCHES) 1868-1967

M= / K	1	2	3	4	5	6	7	8	9	10
1	192.94	106.72	197.59	219.55	197.63	235.98	203.59	218.84	201.25	228.78
2	78.66	80.29	135.94	134.71	141.21	143.79	126.80	130.63	134.51	144.09
3	80.84	88.90	117.87	128.26	121.98	118.75	108.80	121.01	120.31	133.37
4	84.02	83.77	113.88	112.96	99.37	102.15	102.79	108.62	113.58	119.31
5	79.28	85.85	102.53	90.73	87.06	96.66	93.51	103.22	104.21	114.36
6	81.99	81.22	83.27	81.50	85.00	89.65	91.32	97.27	102.66	106.90
7	77.96	64.17	75.19	79.82	79.36	87.42	87.19	96.29	7.26	106.45
8	62.50	59.78	74.89	75.79	79.03	84.57	87.83	92.64	98.44	101.63
9	59.84	61.13	72.79	76.35	76.78	85.29	84.70	93.90	95.84	103.32
10	61.24	61.01	73.93	74.47	78.26	82.63	86.56	92.43	97.81	97.62
11	61.00	63.12	72.46	75.97	76.39	84.52	85.66	94.50	93.03	98.14
12	63.13	62.52	74.01	74.20	76.51	84.00	87.78	90.52	93.47	88.50
13	62.52	64.71	72.40	76.22	78.44	85.91	84.52	90.87	84.68	89.60
14	64.80	64.09	74.63	76.27	80.76	83.10	85.34	82.40	86.10	90.59
15	64.29	66.83	74.77	76.54	78.42	83.01	77.35	83.81	87.15	89.83
16	67.06	67.42	77.15	76.48	79.54	76.03	78.99	84.91	86.74	90.45
17	67.57	70.14	75.26	77.58	71.90	77.57	80.09	84.58	87.42	88.98
18	70.17	68.88	76.26	70.50	73.40	78.78	79.83	85.25	86.27	87.96
19	68.96	70.21	69.16	71.95	74.61	78.59	80.65	84.22	85.44	88.25
20	70.36	63.79	70.70	73.36	74.67	79.53	80.04	83.65	86.04	89.58
21	63.79	65.64	72.04	73.55	75.60	78.99	79.73	94.17	87.20	90.15
22	65.50	67.49	72.19	74.63	75.69	78.71	80.73	85.79	88.12	91.39
23	67.26	67.92	73.34	74.54	75.61	79.59	82.17	86.71	89.47	90.95
24	67.68	69.25	73.44	74.49	76.63	81.09	83.23	88.0[illegible]	89.19	92.81
25	69.11	69.51	73.55	75.41	78.04	82.15	84.67	87.83	91.12	92.86
26	69.44	69.87	74.46	76.72	79.19	83.66	84.60	89.82	91.24	94.82
27	69.88	71.01	75.85	77.97	80.76	83.75	86.67	90.11	93.23	94.10
28	71.00	72.44	77.15	79.61	80.97	85.96	87.04	92.18	92.71	96.73
29	72.52	73.92	78.73	79.92	83.09	86.33	89.06	91.73	95.19	98.00
30	74.05	75.48	79.13	81.96	83.67	88.24	88.65	94.04	96.49	101.39
31	75.61	76.06	81.21	82.63	85.61	87.44	90.92	95.42	99.89	91.31
32	76.23	78.27	81.90	84.61	85.45	90.24	92.35	98.76	89.60	92.31
33	78.50	79.15	83.91	84.57	87.77	91.76	95.73	88.67	90.72	70.45
34	79.43	81.27	83.99	86.88	89.35	95.10	85.65	89.84	69.85	72.44
35	81.57	81.49	86.27	86.52	92.73	85.23	66.93	68.25	70.89	56.38
36	81.86	83.88	87.95	91.64	82.75	66.52	65.30	70.31	54.66	55.78
37	84.35	85.70	91.31	81.87	84.14	64.89	67.43	54.03	54.22	58.20
38	86.17	89.07	81.09	83.23	62.26	67.00	50.95	53.67	56.61	30.84
39	89.58	78.85	82.52	61.56	64.42	50.64	50.67	56.09	29.52	33.42
40	79.37	80.36	60.93	63.69	48.19	50.35	53.06	29.21	32.06	0.0 *
41	80.98	59.50	63.04	48.36	47.70	52.70	27.48	31.85	0.0 *	3.39
42	60.12	61.69	47.77	47.91	50.09	27.38	30.13	0.0 *	3.36	3.35
43	62.24	47.29	47.01	50.20	26.15	30.10	0.0 *	3.24	2.93	5.05
44	47.68	46.60	49.34	26.34	28.85	0.0 *	3.17	2.86	4.64	3.72
45	46.70	48.86	26.47	29.06	0.0 *	3.04	2.46	4.24	2.95	6.93
46	49.03	25.48	29.18	0.0 *	3.05	2.47	3.94	2.73	6.12	8.10
47	25.48	28.21	0.0 *	3.01	2.51	3.93	2.49	5.94	7.29	9.16
48	28.29	0.0 *	2.90	2.12	3.66	2.13	5.69	7.11	3.12	9.36
49	0.0 *	2.89	1.99	3.22	1.85	5.29	6.96	7.92	8.31	8.57
50	2.74	1.54	2.72	0.99	5.04	6.58	7.47	7.73	7.03	9.21

Q(K,M) FOR JAN OF A 100 YEAR PERIOD SANTA BARBARA, CALIF. PRECIPITATION (INCHES) 1868-1967

M= K	1	2	3	4	5	6	7	8	9	10
1	3.93	3.02	4.02	4.10	3.98	4.35	4.01	4.25	3.83	4.15
2	3.09	3.19	3.76	3.74	3.83	3.94	3.77	3.72	3.70	3.74
3	3.18	3.24	3.56	3.70	3.72	3.81	3.52	3.63	3.49	3.64
4	3.23	3.18	3.55	3.62	3.60	3.59	3.54	3.47	3.44	3.52
5	3.20	3.24	3.50	3.53	3.45	3.55	3.39	3.44	3.39	3.48
6	3.23	3.25	3.41	3.38	3.45	3.40	3.39	3.37	3.36	3.37
7	3.21	3.20	3.30	3.40	3.33	3.39	3.35	3.35	3.29	3.36
8	3.15	3.13	3.33	3.29	3.34	3.34	3.35	3.26	3.28	3.23
9	3.11	3.16	3.25	3.32	3.29	3.33	3.25	3.26	3.21	3.22
10	3.15	3.12	3.29	3.28	3.29	3.24	3.26	3.23	3.21	3.14
11	3.11	3.15	3.27	3.29	3.21	3.25	3.22	3.22	3.14	3.14
12	3.15	3.14	3.28	3.21	3.22	3.22	3.22	3.17	3.13	3.05
13	3.13	3.16	3.20	3.21	3.20	3.22	3.13	3.16	3.04	3.04
14	3.15	3.10	3.21	3.18	3.21	3.18	3.17	3.07	3.05	3.07
15	3.11	3.12	3.18	3.19	3.17	3.17	3.07	3.07	3.08	3.04
16	3.13	3.10	3.19	3.16	3.17	3.07	3.07	3.11	3.06	3.04
17	3.11	3.12	3.17	3.16	3.06	3.06	3.10	3.07	3.05	3.04
18	3.12	3.10	3.16	3.06	3.05	3.10	3.06	3.07	3.05	3.01
19	3.10	3.09	3.05	3.05	3.08	3.06	3.06	3.07	3.03	3.05
20	3.10	3.00	3.05	3.08	3.05	3.06	3.07	3.05	3.06	3.06
21	3.00	3.00	3.07	3.05	3.06	3.05	3.05	3.08	3.07	3.10
22	2.99	3.03	3.04	3.05	3.08	3.06	3.09	3.09	3.12	3.09
23	3.02	3.00	3.05	3.07	3.06	3.09	3.10	3.14	3.11	3.11
24	2.98	3.01	3.07	3.06	3.09	3.10	3.14	3.13	3.13	3.12
25	2.99	3.03	3.05	3.08	3.09	3.14	3.13	3.14	3.15	3.13
26	3.01	3.02	3.08	3.08	3.12	3.13	3.14	3.15	3.15	3.17
27	3.00	3.04	3.08	3.12	3.12	3.14	3.15	3.17	3.19	3.19
28	3.03	3.05	3.11	3.11	3.13	3.16	3.17	3.20	3.21	3.21
29	3.04	3.08	3.11	3.13	3.14	3.17	3.20	3.21	3.22	3.25
30	3.07	3.07	3.13	3.14	3.16	3.20	3.21	3.22	3.27	3.30
31	3.06	3.09	3.14	3.16	3.19	3.21	3.22	3.27	3.32	3.19
32	3.08	3.11	3.16	3.19	3.20	3.22	3.27	3.32	3.21	3.22
33	3.09	3.13	3.18	3.20	3.21	3.27	3.32	3.20	3.23	3.06
34	3.12	3.15	3.20	3.21	3.26	3.32	3.20	3.23	3.08	3.09
35	3.14	3.17	3.21	3.26	3.31	3.21	3.23	3.07	3.11	2.94
36	3.16	3.18	3.26	3.31	3.19	3.23	3.07	3.10	2.96	2.92
37	3.17	3.23	3.30	3.19	3.22	3.07	3.10	2.97	2.94	2.95
38	3.22	3.27	3.19	3.21	3.05	3.10	2.96	2.95	2.97	2.75
39	3.26	3.16	3.21	3.05	3.09	2.97	2.94	2.98	2.77	2.79
40	3.15	3.19	3.05	3.09	2.95	2.95	2.97	2.78	2.81	2.60*
41	3.18	3.04	3.08	2.96	2.93	2.97	2.78	2.82	2.62*	2.67
42	3.03	3.06	2.95	2.93	2.96	2.79	2.82	2.63*	2.68	2.67
43	3.05	2.94	2.93	2.96	2.78	2.84	2.63*	2.68	2.68	2.68
44	2.93	2.92	2.95	2.78	2.82	2.65*	2.69	2.68	2.69	2.66
45	2.90	2.94	2.78	2.83	2.64*	2.70	2.65	2.69	2.67	2.70
46	2.92	2.76	2.82	2.64*	2.69	2.69	2.69	2.67	2.71	2.74
47	2.75	2.80	2.64*	2.70	2.69	2.70	2.67	2.71	2.75	2.75
48	2.80	2.62*	2.69	2.65	2.69	2.57	2.72	2.75	2.75	2.75
49	2.62*	2.67	2.68	2.69	2.66	2.72	2.77	2.76	2.75	2.71
50	2.66	2.66	2.68	2.65	2.71	2.77	2.75	2.75	2.71	2.71

QF(K,M) FOR JAN OF A 100 YEAR PERIOD SANTA BARBARA, CALIF. PRECIPITATION (INCHES) 1868-1967

M= K	1	2	3	4	5	6	7	8	9	10
1	50.24	15.25	52.25	55.01	50.73	64.37	52.22	61.65	46.52	59.64
2	18.01	21.63	42.59	41.44	45.06	48.62	43.20	41.75	41.25	43.86
3	21.54	23.62	35.00	40.17	40.84	44.03	33.84	38.19	33.45	39.80
4	23.27	21.33	34.66	36.99	36.57	35.65	34.56	32.03	31.60	35.28
5	22.28	23.31	32.72	33.46	30.67	34.07	26.82	30.79	29.52	33.77
6	23.57	23.82	29.17	28.03	30.85	28.24	28.93	26.28	28.22	29.58
7	22.72	21.77	25.02	28.67	26.03	28.09	27.23	27.69	25.50	29.04
8	20.50	19.16	26.18	24.35	26.51	26.12	27.22	24.29	25.49	24.28
9	18.84	20.49	23.22	25.75	24.60	25.67	23.57	24.21	22.56	23.73
10	20.49	18.76	24.66	24.15	24.63	22.17	24.01	22.90	22.60	20.81
11	19.00	20.13	23.76	24.40	21.46	22.69	22.32	22.47	20.01	20.54
12	20.45	19.56	24.16	21.39	22.08	21.59	22.43	20.76	19.62	17.13
13	19.75	20.28	21.39	21.65	21.08	21.64	20.82	20.33	16.07	16.92
14	20.57	18.29	21.70	20.54	21.61	19.97	20.61	16.84	16.43	18.06
15	18.85	18.91	20.56	20.88	20.20	19.88	16.53	16.86	17.86	16.81
16	19.65	18.21	21.05	19.74	19.99	15.77	16.74	18.24	16.79	16.70
17	18.85	18.71	20.10	19.62	15.83	15.66	17.94	16.99	16.44	16.83
18	19.23	17.97	19.63	15.74	15.72	17.12	16.36	16.76	16.50	15.84
19	18.60	17.70	15.79	15.60	16.75	15.61	16.35	16.90	15.63	17.07
20	18.39	14.28	15.62	16.58	15.48	15.73	16.63	16.17	16.86	17.58
21	14.65	14.18	16.53	15.46	15.80	16.15	15.98	17.28	17.26	19.07
22	14.43	15.33	15.24	15.62	16.50	15.42	17.24	17.83	19.05	18.87
23	15.36	14.22	15.52	16.27	15.85	16.58	17.62	19.44	18.95	19.38
24	14.05	14.61	16.21	15.64	16.94	16.94	19.16	19.09	19.54	19.92
25	14.45	15.26	15.68	16.67	17.07	18.43	18.90	19.58	20.22	20.33
26	15.05	14.87	16.67	16.70	18.25	18.23	19.37	20.07	20.56	21.64
27	14.85	15.91	16.70	17.97	18.07	18.74	19.81	20.61	21.86	22.53
28	15.83	16.05	18.09	17.85	18.50	19.25	20.36	21.70	22.58	23.20
29	16.02	17.25	17.84	18.42	19.04	19.87	21.49	22.32	23.17	24.93
30	17.16	17.06	18.50	18.87	19.70	20.79	21.99	22.63	24.83	26.85
31	16.93	17.79	18.96	19.60	20.03	21.37	22.27	24.46	26.75	22.66
32	17.63	18.34	19.65	20.56	21.32	21.69	24.13	26.29	22.57	23.62
33	18.23	19.11	20.67	21.21	21.63	23.55	25.35	24.01	23.55	17.67
34	19.07	20.19	21.35	21.54	23.48	25.34	21.68	22.92	17.61	18.77
35	20.12	20.88	21.65	23.41	25.29	21.02	22.63	16.98	18.69	13.18
36	20.86	21.22	23.49	25.18	20.95	21.88	16.72	18.11	13.07	12.35
37	21.22	23.05	25.23	20.83	21.81	15.76	17.88	12.89	12.29	13.47
38	23.02	24.77	20.85	21.66	15.64	17.02	12.58	12.19	13.40	5.82
39	24.73	20.55	21.75	15.54	16.90	12.08	11.89	13.31	5.73	7.35
40	20.49	21.47	15.75	16.79	11.90	11.31	13.01	5.86	7.17	0.0 *
41	21.60	15.68	16.82	11.99	[illegible]	12.28	5.72	7.30	0.0 *	2.46
42	15.76	16.68	11.98	11.03	[illegible]	5.53	7.09	0.0 *	2.42	2.56
43	16.63	12.17	10.96	11.69	5.41	7.06	0.0 *	2.12	2.28	3.05
44	12.09	11.16	11.75	5.31	6.95	0.0 *	2.13	2.09	2.82	2.18
45	10.95	11.85	5.27	7.01	0.0 *	1.02	1.95	2.47	1.87	3.94
46	11.71	5.13	6.96	0.0 *	1.98	1.57	2.38	1.59	3.54	5.40
47	4.98	6.82	0.0 *	2.02	1.80	1.35	1.52	3.23	4.99	5.79
48	6.85	0.0 *	1.82	1.67	1.85	0.45	3.35	4.89	5.16	5.72
49	0.0 *	1.84	1.46	1.74	0.70	2.69	5.07	5.06	5.08	4.27
50	1.62	1.37	1.41	0.38	2.70	4.60	4.99	4.75	3.41	4.16

D(K,M) FOR JAN OF A 100 YEAR PERIOD SANTA BARBARA, CALIF. PRECIPITATION (INCHES) 1868-1967

M= K	1	2	3	4	5	6	7	8	9	10
3	3.33	3.19	3.61	3.77	3.44	3.76	3.46	3.57	3.36	3.41
5	3.18	3.29	3.22	3.38	3.06	3.20	3.16	3.11	3.11	3.18
7	2.99	3.11	3.05	3.09	2.93	2.96	2.96	3.07	2.93	3.04
9	2.92	2.97	2.99	2.98	2.97	3.01	2.99	2.93	2.89	2.93
11	2.83	2.86	2.93	2.94	2.96	2.92	2.92	2.87	2.79	2.65
13	2.81	2.89	2.95	2.96	2.96	2.91	2.84	2.85	2.71	2.67
15	2.84	2.90	3.01	2.98	2.93	2.91	2.75	2.67	2.69	2.74
17	2.87	2.93	2.95	2.92	2.77	2.72	2.69	2.74	2.71	2.83
19	2.85	2.88	2.81	2.76	2.76	2.74	2.73	2.78	2.81	2.84
21	2.71	2.74	2.78	2.78	2.78	2.81	2.80	2.79	2.80	2.84
23	2.70	2.74	2.77	2.78	2.81	2.84	2.81	2.80	2.83	2.83
25	2.76	2.75	2.83	2.80	2.87	2.82	2.81	2.81	2.89	2.88
27	2.81	2.81	2.86	2.85	2.83	2.80	2.85	2.86	2.95	2.97
29	2.81	2.83	2.85	2.81	2.87	2.89	2.90	2.96	2.98	3.00
31	2.80	2.83	2.90	2.94	2.96	2.96	2.96	2.99	3.07	2.95
33	2.83	2.90	2.96	2.99	2.95	2.98	3.01	2.91	2.97	2.79
35	2.90	2.96	2.99	3.00	3.03	2.89	2.94	2.79	2.85	2.71
37	2.93	3.00	3.05	2.93	2.93	2.75	2.82	2.70	2.69	2.69
39	3.02	2.92	2.96	2.76	2.79	2.66	2.67	2.69	2.44	2.44
41	2.91	2.76	2.81	2.67	2.64	2.67	2.43	2.44	2.22*	2.27*
43	2.74	2.64	2.64	2.65	2.42	2.43	2.20*	2.28	2.28	2.28
45	2.60	2.65	2.43	2.44	2.21*	2.27*	2.29	2.30	2.26	2.29
47	2.38	2.43	2.22*	2.29*	2.27	2.31	2.31	2.29	2.28	2.29
49	2.20*	2.29*	2.29	2.31	2.26	2.28	2.29	2.27*	2.26	2.28

DF(K,M) FOR JAN OF A 100 YEAR PERIOD SANTA BARBARA, CALIF. PRECIPITATION (INCHES) 1868-1967

M= K	1	2	3	4	5	6	7	8	9	10
3	51.84	39.41	62.22	64.45	55.87	65.14	57.12	57.40	51.34	50.16
5	44.76	43.77	44.72	47.64	38.64	40.82	43.85	37.17	40.28	40.11
7	35.97	36.15	37.19	34.99	32.92	30.30	34.75	35.72	31.90	33.71
9	32.89	29.89	34.18	30.08	34.43	32.49	35.83	29.35	29.98	28.72
11	29.07	24.96	31.56	28.51	33.98	28.38	32.69	26.85	25.63	25.33
13	27.80	26.54	32.70	29.29	34.18	28.06	29.29	25.78	22.17	17.65
15	29.23	26.85	35.50	30.03	32.83	27.91	25.02	17.97	20.98	20.37
17	30.68	28.25	32.72	27.56	25.33	19.77	22.13	21.06	22.19	24.38
19	29.88	26.10	26.49	20.57	24.91	20.48	23.98	22.71	26.54	25.12
21	23.42	19.74	25.00	21.59	26.13	23.49	27.16	23.22	25.29	24.84
23	23.01	19.64	24.67	21.33	27.13	24.90	27.92	23.65	27.42	24.69
25	25.79	20.15	27.07	22.44	30.07	23.98	27.98	24.00	29.87	26.65
27	27.75	22.97	28.36	24.31	28.41	23.23	29.80	26.29	33.13	30.44
29	27.97	23.57	28.26	22.71	29.98	26.30	31.87	31.51	34.28	31.94
31	27.50	23.86	30.21	28.16	34.21	30.32	34.44	31.92	33.17	29.73
33	29.02	26.76	32.95	30.34	33.54	30.93	36.93	28.32	33.69	22.95
35	31.89	29.28	34.20	30.83	37.44	27.11	33.47	23.05	28.62	19.06
37	33.56	31.26	37.09	28.12	32.56	20.91	28.30	19.09	21.30	18.47
39	37.49	27.66	32.99	20.68	26.44	16.79	21.41	18.85	9.97	7.34
41	32.64	20.88	26.33	16.67	19.81	17.37	10.32	7.62	0.0 *	0.0 *
43	24.91	15.45	18.59	15.51	9.69	6.77	0.0 *	0.60	2.94	0.49
45	18.31	16.11	9.04	6.65	0.0 *	0.0 *	4.04	1.42	1.95	0.83
47	8.32	6.14	0.0 *	0.0 *	2.85	1.44	4.85	1.12	2.58	0.66
49	0.0 *	0.0 *	3.04	0.73	2.53	0.42	4.30	0.0 *	1.91	0.19

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13. ABSTRACT

Rainfall and other variables with similarly skewed distributions are hard to characterize climatically due to their extreme variability. The arithmetic mean, generally used, is greatly influenced by extreme values. For rainfall data from 219 stations located in the western United States, the median was found to be a more representative value, and somewhat better than the mean for predicting future rainfall amounts. Some monthly precipitation frequency distributions are so greatly skewed that values smaller than the mean occur 90% of the time. Because any single measure of central tendency is inconclusive, measures of absolute and relative variability are summarized. Maps of percentage occurrence of the mean, ratio between median and mean, coefficient of variation (CV), and relative variability (Vq) are presented for the mid-season months--Jan, Apr, Jul, and Oct.

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Security Classification

AD 672-268

SAN FERNANDO VALLEY STATE COLLEGE
NORTHRIDGE, CALIFORNIA

11 September 1968

ERRATA SHEET FOR

CLIMATIC NORMALS AS PREDICTORS

Part 1: Background AFCRL 67-0313 - 65[illegible]

Part 3: Median vs. Mean AFCRL-68-0255 - 672[illegible]

In Part 1, distributed in June 1967, the contract number on the cover should be corrected to read:

AF19 (628) - 5716

In Part 3, distributed in July 1968, in Form DD 1473 (the final page of report), block 9b should contain the number, which also appears on the cover:

AFCRL-68-0255

In Part 3 also, page 81, entitled "Climatic Prediction," should be marked as the start of

APPENDIX II

Part 2 and 4 are in preparation, and will receive the same distribution as the first two reports.

Arnold Court
Principal Investigator